UNIVERSITY OF ALBERTA

THE EFFECTS OF PARASITES AND PESTICIDES ON CALIFORNIA QUAIL IN THE OKANAGAN VALLEY, BRITISH COLUMBIA.

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "The Effects of Parasites and Pesticides on California Quail in the Okanagan Valley, British Columbia", submitted by Reginald Edmund Chandler in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

A total of 131 California quail (*Lophortyx californicus*) were collected by hunting and trapping from four study areas in the Okanagan Valley of British Columbia during the summers of 1965 and 1966. All of these birds were examined for helminths and ectoparasites. The following species were found parasitizing California quail: two tapeworms, *Rhabdometra odiosa* and *Choanotaenia infundibulum*, one nematode *Acuaria spinosa*, two Mallophaga, *Goniodes stefani* and *Colinicola docophoroides*, a hippoboscid fly, *Ornithomyia fringillina*, and a tick, *Haemaphysalis leporispalustris*. *R. odiosa* and *Co. docophoroides* were recovered from quail from all areas; the other parasites were less common and more restricted in distribution. *Ch. infundibulum*, *A. spinosa*, and *O. fringillina* have never been reported from California quail before. Overall extensity and intensity for *R. odiosa* from adult California quail were 53.8 per cent and 13.5 respectively; from juvenal quail, 45.8 per cent and 22.4; for *Ch. infundibulum* from adult quail the extensity and intensity were 1.5 per cent and 2; from juvenal quail, 9.7 per cent and 1.7. The overall percentage of adult quail infected with *Co. docophoroides* was 6.2; for juvenal quail 40.3. Only 3 specimens of *G. stefani* were recovered. Only one specimen each of *O. fringillina* and *H. leporispalustris* was taken.

Brain tissue from all of the adult female and juvenal quail collected was analyzed by the Ontario Research Foundation for the following pesticide residues: heptachlor, heptachlor

epoxide, dieldrin, DDT, its metabolites DDE and DDD, lindane, endrin, and methoxychlor. In addition 11 samples of eggs and ovaries with preovulatory follicles were analyzed for the above pesticides. So far only the analyses of the 1965 samples have been received. No methoxychlor residues were found in any of these samples, lindane and endrin were found in one bird each, and the others were present in most of the birds analyzed. The ovaries and eggs had concentrations of pesticides about three times as high as the brain tissue of the corresponding birds. All pesticide values were low. The average overall total pesticide value from adult females from the sprayed areas was 0.6 p.p.m.; for juveniles it was 0.4 p.p.m. The highest total residue value from any one individual was 1.8 p.p.m.

There was no evidence that any of the parasites or pesticides caused any detrimental effect on any of the California quail in the study areas, although a few birds had levels of dieldrin as high as or higher than that reported by Labisky and Lutz (1967) in a pheasant that showed symptoms of pesticide poisoning.

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INTRODUCTION

The Okanagan Valley, a relatively broad, irregularly shaped depression between the Columbia and Cascade Mountain Ranges in south central British Columbia, extends from Salmon Arm south to the internation border. Most of the valley is located in either the Dry Forest Biotic Area or the Osoyoos-Arid Biotic Area as defined by Munro and Cowan (1947).

The Osoyoos-Arid Biotic Area extends from the north end of Skaha Lake south to the international boundary and is characterized by mild winters, hot summers, and an average annual precipitation under 8 inches (Munro and Cowan, 1947; Cowan and Guiguet, 1965). This area extends altitudinally from the valley floor up to 1,000 feet (Cowan and Guiguet, 1965).

The Dry Forest Biotic Area, which includes nearly all the remainder of the Okanagan Valley, is found north of, and altitudinally above the Osoyoos-Arid Biotic Area (Munro and Cowan, 1947). This biotic area is characterized by mild winters, hot summers, and an average annual precipitation of between 8 and 16 inches (Cowan and Guiguet, 1965).

The soil in both of these biotic areas is fertile. With irrigation, fruit trees grow well on these soils, and fruit is the main agricultural crop in the Valley. Most of the orchards around the Okanagan and Skaha Lakes are located on benchlands that are composed of silt loam soils (Bowman, 1950).

The first apple trees in the Okanagan Valley were planted in 1862 by the Oblate Fathers at the Okanagan Mission, just southeast of Kelowna (Fisher, 1964). Between 1862 and 1890

some more trees were planted by stock ranchers north of Kelowna, in the Kelowna district, and in Penticton (Fisher, 1964). The first commercial plantings were made in 1892 (Bowman, 1950) at the flats near Kelowna (Fisher, 1964).

At this time (early 1890's) there were 20,000 cattle in the area between Osoyoos and Enderby (Bowman, 1950) and dairy products were the main agricultural product. There is still a fair amount of cattle grazing done above the orchard lands, but it is mostly beef cattle now.

Between 1900 and 1914 there was a rapid expansion of commercial orchard cultivation on the irrigated benchlands (Bowman, 1950). In 1960 there were some 32,792 acres of orchards in the Okanagan and Similkameen Valleys (Fisher, 1964). In the Okanagan Valley orchards are found from just north of Vernon south to the international border (Fisher, 1964).

All orchards in the Similkameen and Okanagan Valleys are irrigated. In the Penticton area most of the irrigation is done by sprinklers which are fed by water carried from mountain reservoirs down to the orchards by flumes. In the Oliver area most of the orchards are sprinkler irrigated by water pumped from the Okanagan River.

As early as 1910, just after the orchards in the Okanagan Valley had become firmly established, some growers were spraying for aphid and blister mite control (Bowman, 1950). In most cases a dormant spray (a spray applied before the buds have opened) of lime-sulphur was the only form of control used (Bowman, 1950). In the early 1930's lead arsenate was the common orchard spray used against codling moths (*Carpocapsa pomonella*)

(Bowman, 1950). By 1940 most orchards had excessive arsenical residues from the lead arsenate sprays and so cryolite (sodium aluminum fluoride), supplemented by a nicotine - bentonite - summer oil mixture, was used in its place (Bowman, 1950). In 1945 phenothiazine was used against codling moths; this was replaced in 1947 by DDT (chemical names for this and other pesticides are given in Table I) (Bowman, 1950). Now azinophos-methyl, or, to a lesser extent Sevin or Diazinon have replaced DDT for codling moth control (Fisher, 1964). DDT is still used for certain pests, such as the oystershell scale (*Lepidosaphes ulmi*) and peach tree borers (*Sanninoidea* spp.) (B. C. Spray Calendar, 1966).

For the control of mites rotenone and monethanolamine were used until 1948 when these miticides were replaced by Parathion (Bowman, 1950). Now Kelthane, tetradifon, Ethion, or Karathane are most commonly recommended for the control of these pests (B. C. Spray Calendar, 1966).

The pesticides most commonly used at present in the orchards of the Okanagan Valley, in decreasing order of importance are: azinophos-methyl, tetradifon, DDT, Kelthane, Cyprex, Sevin, Thiodan, Ethion, Perthane, Diazinon, Binapacryl, Malathion, Morestan, and dieldrin (R. Sparke, 1964, in letter to V. Lewin).

In the 1950's DDT was applied at rates that may have totalled up to 40 to 60 lbs/acre/year (Genelly and Rudd, 1956). Now only about 25 lbs/acre/year of 50 per cent wetable powder is normally used (B. C. Spray Calendar, 1966). This amounts to about 12.5 lbs/acre/year of pure DDT. At present, on the average, the total amount of pesticides used throughout the entire valley

Table I. Chemical names of pesticides mentioned in text.

Common name	Chemical name
Azinophos-methyl (Guthion)	*O,O*-Dimethyl *S*-(4-oxobenzotriazino-3-methyl) phosphorodithioate
Binapacryl (Morocide)	2-sec-butyl-4,6-dinitrophenyl 3-Methyl-2-butenoate
Chlordane	1,2,4,5,6,7,8,8-Octachloro-2,3,2a,4,7,7a-hexahydro-4,7-methanoindene
Cyprex	*n*-Dodecylguanidine acetate
DDD	2,2 Bis (*p*-chlorophenyl)-1,1-dichloroethane
DDE	2,2 Bis (*p*-chlorophenyl)-1,1-dichloroethylene
DDT	2,2 Bis (p-chlorophenyl)-1,1,1-trichloroethene
Diazinon	*O,O*-Diethyl *O*-(2-isopropyl-4-methyl-6-pyrimidinyl) phosphorothioate
Dieldrin	1,2,3,4,10,10-hexachloro-exo-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-*endo*-*exo*-5,8 dimethanonaphthalene
Endrin	1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-*endo*-1,4-endo-5,8-dimethanonaphthalene
Ethion	*O,O,O',O'*-Tetraethyl *S,S'*-methylene bisphosphorodithioate
Heptachlor	1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-*endo*ethanoindene gamma-1,2,3,4,5,6-hexachloro*cyclo*hexane
Karathane	2,4-Dinitro-6-(2-octyl) phenyl cortonate
Kelthane	4,4'-Dichloro-*a*-trichloromethylbenzhydrol

Table I. (cont.)

Common name	Chemical name
Lindane	gamma-1,2,3,4,5,6-hexachloro*cyclo*hexane
Malathion	*O*,*O*-Dimethyl-S-1,2-di(ethoxycarbamyl)ethyl phosphorodithioate
Methoxychlor	2,2-Bis (P-methoxyphenyl)-1,1,1-trichloroethane
Morestan	6-Methyl-2-3 quinoxalinedithiol cyclic carbonate
Parathion	*O*,*O*-Diethyl *O*-*p*-nitrophenyl phosphorothiate
Perthane	1,1-bis (*p*-ethylphenyl)-2,2-dichloroethone
Phenothiazine	Dibenzo-1,4-thiazine
Sevin	1-Naphthyl N-Methylcarbamate
Tetradifon (Tedion)	2,4,5,4'-Tetrachlorodiphenyl sulphone
Thiodan	6,7,8,9,10,10-Hexachloro-1,5,5a,6,9,9a-hexahydro-6-9-metheno-2,4,3-benzo-dioxalhiepin-3-oxide

is 26.3 lbs/acre/year (R. Sparke in letter to V. Lewin).

Of the commonly used pesticides listed above, Sevin is a persistent carbamate which has a low acute toxicity (Martin, 1961); Binapacryl is a non-persistent, fairly dangerous dinitro organic compound (Canada Department of Agriculture, 1966); DDT and dieldrin are persistent chlorinated hydrocarbons which can be harmful to wildlife (Martin, 1961; Rudd, 1964); and Kelthane, Tedion, and Perthane are persistent chlorinated hydrocarbons which have low acute toxicities (Martin, 1961).

Of these only DDT, its metabolic breakdown products (DDD and DDE), and dieldrin could be analysed for by the Ontario Research Foundation (where the analyses were done) (W. Stevens, pers. comm.). Also analysed for were heptachlor, its metabolite heptachlor epoxide, lindane, endrin, and methoxychlor.

Heptachlor is a persistent chlorinated hydrocarbon which can be extremely dangerous to wildlife (Rudd, 1964). It is not one of the recommended sprays for pest control in the Okanagan Valley (B. C. Spray Calendar, 1966).

Lindane is a somewhat persistent chlorinated hydrocarbon (Fernald and Shepard, 1955) which is dangerous to warm-blooded animals (Martin, 1961). This insecticide is used sparingly on young, non-bearing trees (B. C. Spray Calendar, 1966).

Endrin, an isomer of dieldrin, is also a persistent chlorinated hydrocarbon (Spector, 1956) which is even more toxic than dieldrin to wildlife (Martin, 1961). This insecticide is not among those recommended for use in the Okanagan Valley (B. C. Spray Calendar, 1966).

Methoxychlor, a chlorinated hydrocarbon, is not persistent

(Spector, 1956) and is not nearly as toxic to wildlife as DDT when used at the recommended dosages (Reid, 1951). Although not used on commercial orchards (B. C. Spray Calendar, 1966), it was at one time considered as a replacement for DDT (Bowman, 1950; Reid, 1951).

All of the insecticides that were analysed for affect the nervous tissue, and, with the exception of methoxychlor, are stored in the body fat of animals (Martin, 1961; Spector, 1956).

There are four main types of sprayers used in the Okanagan Valley. The conventional handgun sprayer achieves almost perfect coverage of orchard trees and can cover from 3 to 5 acres/day (Bowman, 1950). This was the sprayer used by the orchardist on study area number 1. Speed sprayers, which can cover up to 15 acres/day, operate by discharging insecticides into a high volume air stream, spraying to both sides simultaneously (Bowman, 1950). Concentrate sprayers are similar to speed sprayers, but they achieve better coverage on the top of the trees (Bowman, 1950). This is now the most common type of sprayer used in the valley (Fisher, 1964), and was the type used by the owner of study area number 2. The fourth type of sprayer is a steam sprayer, which is a concentrate sprayer that atomizes liquid insecticides by means of a high velocity steam blast (Bowman, 1950). All of these sprayers are fairly selective, and deposit most of the spray on the trees rather than on the cover crop beneath the trees (Bowman, 1950). Even with these sprayers, however, concentrations of DDT on the cover crop foliage between orchard trees,immediately after spraying, may be as high as 600 p.p.m. (Reid, 1951).

There have been reports of considerable mortality among ground dwelling birds in the orchard areas of British Columbia and Washington (Barnett, 1950). There has, however, been no noticable decline in the reproductive success of the species concerned (Genelly and Rudd, 1956). Bowman (1950) found that sprayed orchards in the Okanagan Valley had 37 per cent fewer birds than did non-sprayed orchards. The sprayed orchards were sprayed with DDT, Parathion, and, on an experimental basis, methoxychlor. Bowman thought most of the difference in bird populations between the two types of orchards was caused by the cutting of the cover crop between the trees and by the disturbance of men and equipment in the sprayed orchards. He did find, however, 11 dead or 'sick' birds in the sprayed orchards; none were found in the non-sprayed orchards. No California quail (*Lophortyx californicus*) were seen by Bowman in any of his study areas. In the Okanagan Valley there has also been some mortality of ring-necked pheasants (*Phasianus colchicus*) (Rye, in Bowman, 1950).

Although California quail (Fig. 1) were introduced on Vancouver Island as early as 1860 or 1861 they were not introduced into the lower mainland of British Columbia (the Fraser Valley area) until the 1890's; further introductions were made near Nicola (in the southern interior of British Columbia) in 1908 and 1910 (Carl and Guiguet, 1958). The Nicola birds may have spread southward to populate the Similkameen Valley areas (Carl and Guiguet, 1958). The first introductions into the southern Okanagan Valley were made about 1900 (Taverner, 1934) and further introductions into this area were made in 1912

Fig. 1. California quail (adult male above, adult female below).


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(Lewin, 1965). Birds in the Oliver-Osoyoos area may have been derived from birds moving southward from Penticton (Lewin, 1965), or from birds moving northward from Washington state (Munro and Cowan, 1947).

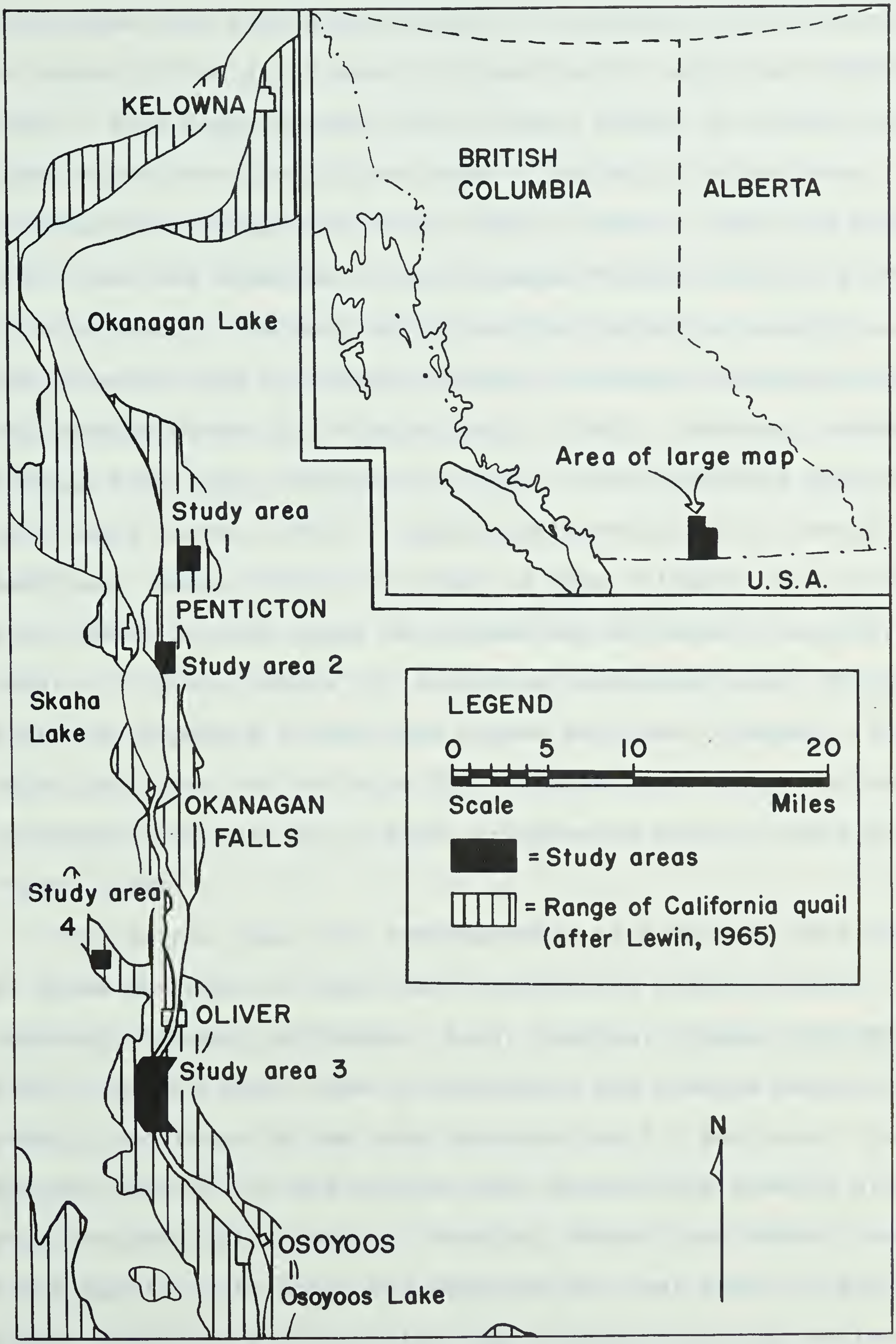
At present California quail are found on Vancouver Island from Comax south to Victoria, rarely in the Fraser Valley, from Vernon south to the international border in the Okanagan Valley, and from Hedley south to the international boundary in the Similkameen Valley (Lewin, 1965; Carl and Guiguet, 1958; Guiguet, 1961). There is also an isolated population near Sidley, British Columbia (Lewin, 1965). The present range of California quail in the southern Okanagan Valley is shown in Fig. 2.

Very little has been done on the general biology of the California quail in British Columbia. The following information is mainly from studies done elsewhere, mostly in California.

California quail, like all North American quail, are ground dwelling birds, but, unlike most quail, they normally roost each night in trees or tall shrubs (Bent, 1932). Except during the nesting season, when the birds are in pairs, California quail form coveys of from 10 to 200 birds (Edminster, 1954). The size of the covey appears to be governed by food supply and the proper type and spacing of habitats providing shelter (Edminster, 1954). The coveys usually break up into pairs in March in California (Bent, 1932). In British Columbia most pairs are formed by the end of May or early June (personal observations).

California quail are ground nesters, most nests being placed under dense shrubs or concealed in grass or weeds (Leopold, 1959). These birds are persistent in their nesting

Fig. 2. Map showing location of study areas and range of California quail in the southern Okanagan Valley. The range of California quail is based on Lewin (1965).


KELOWNA
Okanagan Lake
Study area 1
PENTICTON
Study area 2
Skaha Lake
OKANAGAN FALLS
Study area 4
OLIVER
Study area 3
OSOYOOS
Osoyoos Lake
BRITISH COLUMBIA
ALBERTA
Area of large map
U.S.A.
LEGEND
0 5 10 20
Scale
Miles
= Study areas
= Range of California quail (after Lewin, 1965)
N

activities, and a high percentage of the females will attempt to renest if the first nest is unsuccessful (Emlen and Glading, 1945). This helps account for the wide spread in the age of young birds found in a given area in the fall, as has been reported from Washington state (Jewett, Taylor, Shaw and Aldrich, 1953), and was observed in the Okanagan Valley during the course of this study. The peak of the nesting period is usually in May or early June in British Columbia (personal observations). The average clutch is 14 eggs (Lewin, 1963). Renests, however, average fewer eggs (Edminster, 1954). The incubation period is 22 days (Lewin, 1963). Usually only one brood is reared each year (Bent, 1932), but there is some evidence that during rainy years in arid areas two broods may be raised (Leopold, 1959). In Chile (where it is also an introduced bird) California quail are reported to rear two broods each year (Johnson, 1965). Young quail can run and hide from enemies from almost the moment of hatching and can fly a short distance at about 10 days of age (Bent, 1932).

California quail are predominantly herbivorous; only one to three per cent of their food consists of animal matter (Grinnell, Bryant and Storer, 1918; Glading, Biswell and Smith, 1940). In one study done in California the average amount of animal food found in the crop contents was 0.5 per cent. In the spring, however, it was noticed that pre-nesting females ate about four per cent animal matter (Glading, Biswell and Smith, 1940). Young quail, up to about six weeks of age, eat about 33 per cent animal food but, even at this, they consume much less matter than do most young gallinaceous birds (Edminster, 1954). California

quail are very regular in their feeding habits and usually frequent the same feeding areas time after time (Bent, 1932). They usually feed in clearings or in areas of sparse vegetation (Emlen and Glading, 1945). There are two main feeding periods; one beginning shortly before sunrise and lasting for about two hours, and the other from about two hours before sunset until roosting time, just after sunset (Glading, Biswell and Smith, 1940). The feeding during the evening period is usually more intense than the one during the morning (Glading, Biswell and Smith, 1940). During the middle of the day California quail usually congregate near the drinking places or else rest in the shade of trees and shrubs in the loafing areas (Bent, 1932).

California quail, as a rule, are sedentary birds. At eight weeks old the average size of the home range for the young birds in the covey is between 10 to 30 acres. The winter covey, which has the widest home range of all, usually stays within an area of 25 to 50 acres, though, if molested or suffering from an acute food shortage, may move as much as two miles (Edminster, 1954).

The overall distribution of California quail is limited by a combination of temperature, snow, and aridity (Edminster, 1954). They must have daily access to water in some form (Emlen and Glading, 1945). They do not occur in areas that have more than 40 inches of precipitation per year as snow (Lewin, 1965). They are not adapted to living in freezing temperatures (Edminster, 1954). During the winter of 1964-1965 in the Okanagan Valley when the temperature fell below -20°C for a few days, there were several reports of California quail suffering from frozen feet

(D. Spalding, pers. comm.).

The following habitat features are necessary for good populations of California quail: low trees or tall shrubs amid intervening areas of open ground with low herbaceous plants, patches of dense shrubs for escape cover and daytime loafing, and water within daily reach (Pough, 1957). Any farming operations that create broad expanses of single vegetation types (such as extensive orchards) are not favorable to California quail (Emlen and Glading, 1945). In the Okanagan Valley, this species is closely associated with orchards and irrigated lands (Lewin, 1965), especially around the edges of such areas (personal observations).

Except for the studies done by O'Roke (1928 and 1932) on *Haemoproteus lophortyx*, a blood protozoan, Herman and Chattin (1943) on coccidiosis, and Krogsdale (1950) on *Rhabdometra odiosa*, which is the only cestode species that has been previously reported from these birds,very little has been done on the parasites of California quail.

The following species of nematodes have been reported from California quail: *Syngamus trachea* by Herman (1945), *Capillaria contorta* by Kasimov (1956), *Habronema incerta* by Cram (1934), *Ascaridia lineata* by Wehr (1933), and *Lophortofilaria californiensis* by Wehr and Herman (1956). Of these, only *L. californiensis* has been found in natural populations of quail.

The following species of lice have been reported from California quail: *Colinicola docophoroides* by Emerson (1951), *Lagopoecus gambeli* by Spencer (1957), *Goniodes stefani* by Emerson (1964), and *G. ovoidalis* by Malcomson (1960).

The following species of hippoboscid flies have been reported from California quail by Bequaert (1957): *Stilbometopa impressa* and *Lynchia hirsuta*.

Ticks of the species *Haemaphysalis leporispalustris* and *Argas miniatus* have been previously reported from California quail (Bishopp and Trembley, 1945).

Mites have also been reported from California quail (Edminster, 1954).

No studies, except for the present study, one by Spencer (1957) on lice of British Columbia birds, and one now in progress by Eugene Liburd on coccidiosis, have ever been done on California quail in British Columbia.

The present study was concerned with the helminths and ectoparasites of California quail, their effects on the birds, and the effects of certain pesticides on wild populations of this species.

METHODS

Four study areas were selected; two of these were in sprayed orchards. In one of these, study area number 2, it appeared that the owner had not been spraying because of extensive frost damage to his apricot trees earlier that year. This area was then abandoned as it was felt that birds should be collected from an actively sprayed orchard in order to properly assess the effects of pesticides on California quail. The second orchard area, study area number 1, was selected to overcome this problem. The third study area was near sprayed orchards and the fourth study area, which served as an imperfect control, was in a non-sprayed area.

All California quail were secured by hunting or trapping. The traps were similar to those described by Lewin, 1963. All of the traps were baited with canary seed. Traps were kept in operation in each of the study areas throughout the two summers. Traps were checked at least once a day, usually during the evening. During the trap checking periods, any quail seen were collected by shooting. Any quail trapped were then removed from the traps and were kept alive overnight in a burlap sack and then killed by thoracic compression (by squeezing the ribs just below and behind the wing insertion) and autopsied the following morning. All birds that were shot were autopsied as soon as possible.

All birds were examined qualitatively for external parasites by carefully looking through the feathers. Very light infection would probably be missed by this procedure, but it is assumed that this method would give a usable index to the population of lice on the different study areas. All external parasites were killed and preserved in 75% alcohol. They were later prepared

by dissolving everything but the chitin in cold KOH for 24 hours, washing in water, dehydrating in ethyl alcohols of increasing concentration and clearing in carbol xylene and xylene. They were then mounted in balsam.

All birds were examined quantitatively for internal parasites. Nematodes were relaxed in warm water, then fixed and preserved in AFA (alcohol-acetic acid-formaldehyde mixture). All nematodes were later cleared in creosote for study. Cestodes were also relaxed in water and then fixed and preserved in AFA. A representative sample from each infected bird was later stained with Erlich's Haematoxylin, Chubb's Haematoxylin, Horen's Trichrome, or Semichon's Acetocarmine and mounted in balsam.

All adult females, juveniles, ovaries with preovulatory follicles, and the single oviducal egg recovered were analyzed for pesticides by the Ontario Research Foundation for the Canadian Wildlife Service. All analyses were done by gas liquid chromatography; the results were confirmed by thin layer chromatography. The pesticides analyzed for were: heptachlor, its metabolite heptachlor epoxide, dieldrin, methoxychlor, endrin, lindane, DDT, and its metabolic breakdown products DDD and DDE. As all birds were eviscerated, and, as the amount of body fat on California quail is very low, nearly all of the residue analyses were done on brain tissue; a few were done on breast muscle tissue, but these are not included in the average residue values reported here.

On most birds an emaciation index (Cornwell and Cowan, 1963) was taken on the breast muscle. This index is the depth of the breast muscle one centimeter from the sternum expressed as a

percentage of the depth of the muscle at the sternum. The method of killing trapped birds (thoracic compression) in no way altered the breast muscle placement or contour. The emaciation index reflects the general condition of the bird; the higher the index value, the better is the condition of the bird. Indices calculated from the breast muscle contour diagrams of bobwhite quail in Leopold (1933) suggest that emaciation index values higher than 100 indicate excellent condition; values from 75 to 100 good to excellent condition; values from 50 to 75 fair to good condition; values from 25 to 50 poor to fair condition, and that birds with values below 25 usually die.

All juvenal birds were aged by primary feather replacement (Raitt, 1961).

Observations were made on the number of young in each study area and from this a rough calculation of the number of young per brood was made as an indicator of the reproductive success of the species in each of the study areas.

Nomenclature for birds follows the A.O.U. checklist, 5th edition (1957) for nearctic species and follows Vaurie (1959 and 1965) for palearctic species; lice are named according to Emerson (1964); the nomenclature for the helminth parasites follows that used by Yamaguti (1959; 1961).

In the text no distinction is made between adults and yearlings (those in an "immature" plumage), although the two classes are distinguished in Appendix II.

DESCRIPTION OF STUDY AREAS

The approximate location of each of the four study areas, along with the range of California quail in the southern Okanagan Valley, is shown in Fig. 2.

Study area number one (Fig. 3) is a sprayed orchard located four miles north of Penticton on the east side of Okanagan Lake. It is approximately 30 acres in size and contains 10 acres of mature orchard and about two acres of non-producing trees. The mature orchard is made up mainly of apple and pear trees, but with a few apricot, peach, and cherry trees. This study area is located in the Dry Forest Biotic Area. The bushes in the gully at one end of the study area (Fig. 4) and along the flume provide good escape cover for California quail. The brush piles in the gully (Fig. 5) also provide good escape cover. Using the criteria of Emlen and Glading (1945), this area would be considered fair habitat for quail. Quail were collected from this area from the end of July until mid September in 1965, and from mid May until mid September in 1966. One additional specimen was collected in May, 1965.

Study area number two (Fig. 6), also a sprayed orchard, is located 4 miles south of Penticton on the east side of Skaha Lake. The orchard area, about 30 acres in extent, is composed mainly of apricot trees, with a few peach and cherry trees. The entire study area is about 145 acres in size. Several brush piles are located at the edge of the orchard areas (Fig. 7). The several large rock outcrops in this area have shrubs and trees growing around their bases (Fig. 8). They provide good escape

cover and loafing areas for California quail. This study area is located at the edge of the Osoyoos-Arid Biotic Area. It would be considered fair to good habitat for California quail (Emlen and Glading, 1945). Birds were collected from this area from mid May to the end of July in 1965 and in May in 1966.

Study area number three (Fig. 9) is an area adjacent to sprayed orchards on the levee about 6 miles south of Oliver. All California quail were collected at least 1/4 mile from the nearest orchard. Several brush piles (Fig. 10) and the riparian growth at the edge of the levee (Fig. 11) and around the numerous pools left after the levee had been built provide good habitat for California quail. However, the open or orchard areas are too extensive for this entire area to be considered good quail habitat; most of it would be classed as poor California quail habitat (Emlen and Glading, 1945). This study area is located in the Osoyoos-Arid Biotic Area. California quail were collected from this area from the end of June to the end of August in 1965 and during July and August in 1966.

Study area number four (Fig. 12), located 2-1/2 miles north and 2 miles west of Oliver, is in a non-sprayed area about 4 miles from the nearest sprayed orchard. This area is in the Dry Forest Biotic Area. Most of the area is covered with ponderosa pine, with shrubs and deciduous trees near the stream, and with a few open areas (Fig. 13) and brush piles (Fig. 14) scattered throughout. This area would be classed as marginal for California quail (Emlen and Glading, 1945). Specimens were collected from this area from mid June to mid August in 1965. No California quail were collected from this area during the summer of 1966.

Fig. 3. Map of vegetation types and trap locations on study area 1.

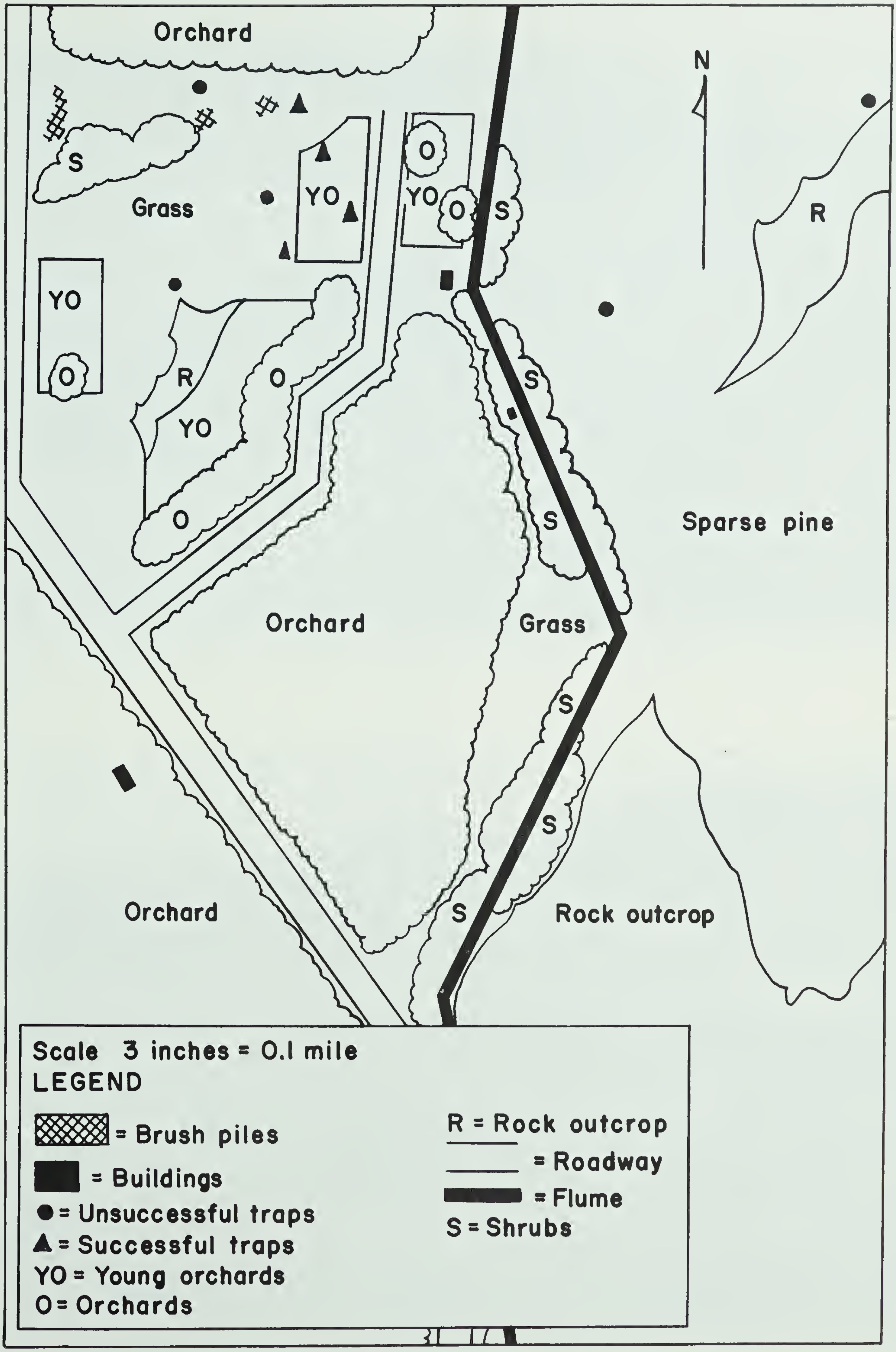
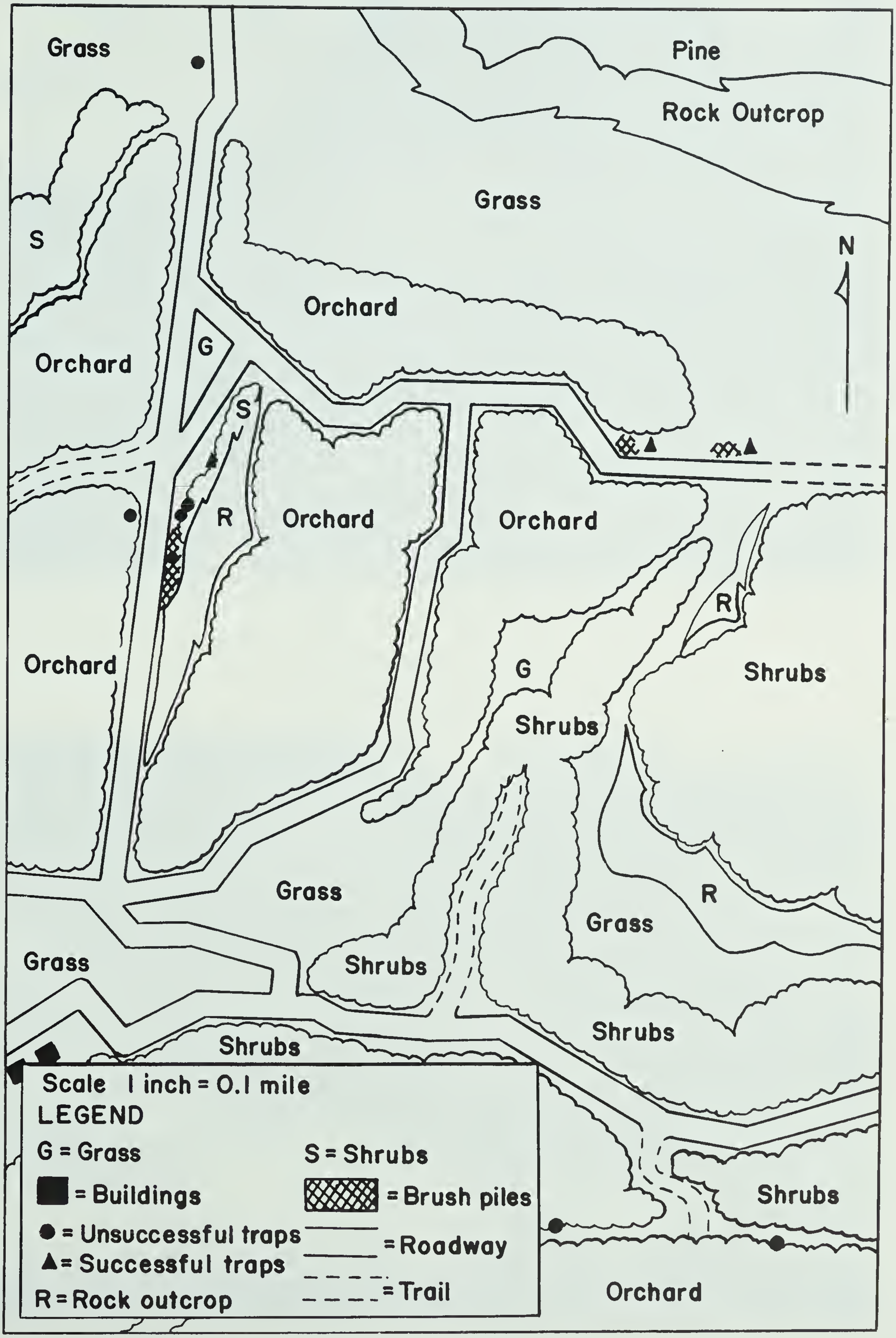

Orchard
N
S
Grass
YO
O
YO
O
S
R
YO
O
R
O
YO
O
S
S
Sparse pine
Orchard
Grass
S
S
Orchard
S
Rock outcrop
Scale 3 inches = 0.1 mile
LEGEND
= Brush piles
= Buildings
● = Unsuccessful traps
▲ = Successful traps
YO = Young orchards
O = Orchards
R = Rock outcrop
= Roadway
= Flume
S = Shrubs

Fig. 4. Bushes in the gulley at the north-west corner of study area 1. Areas such as these provide good escape cover for California quail.

Fig. 5. Brush piles in the gulley at the north-central part of study area 1. Brush piles also provide good escape cover for California quail.

Fig. 6. Map of vegetation types and trap locations on study area 2.



Grass
Pine
Rock Outcrop
Grass
S
N
Orchard
G
Orchard
S
R
Orchard
Orchard
R
Orchard
G
Shrubs
Shrubs
Shrubs
Grass
R
Grass
Grass
Shrubs
Shrubs
Shrubs
Scale 1 inch = 0.1 mile
LEGEND
G = Grass
S = Shrubs
= Buildings
= Brush piles
= Unsuccessful traps
= Successful traps
= Roadway
= Trail
R = Rock outcrop
Shrubs
Orchard

Fig. 7. Brush piles at the north end of study area 2.

Fig. 8. Shrubs and trees growing around rock outcrop at the west end of study area 2.

Fig. 9. Map of vegetation types and trap locations on study area 3.

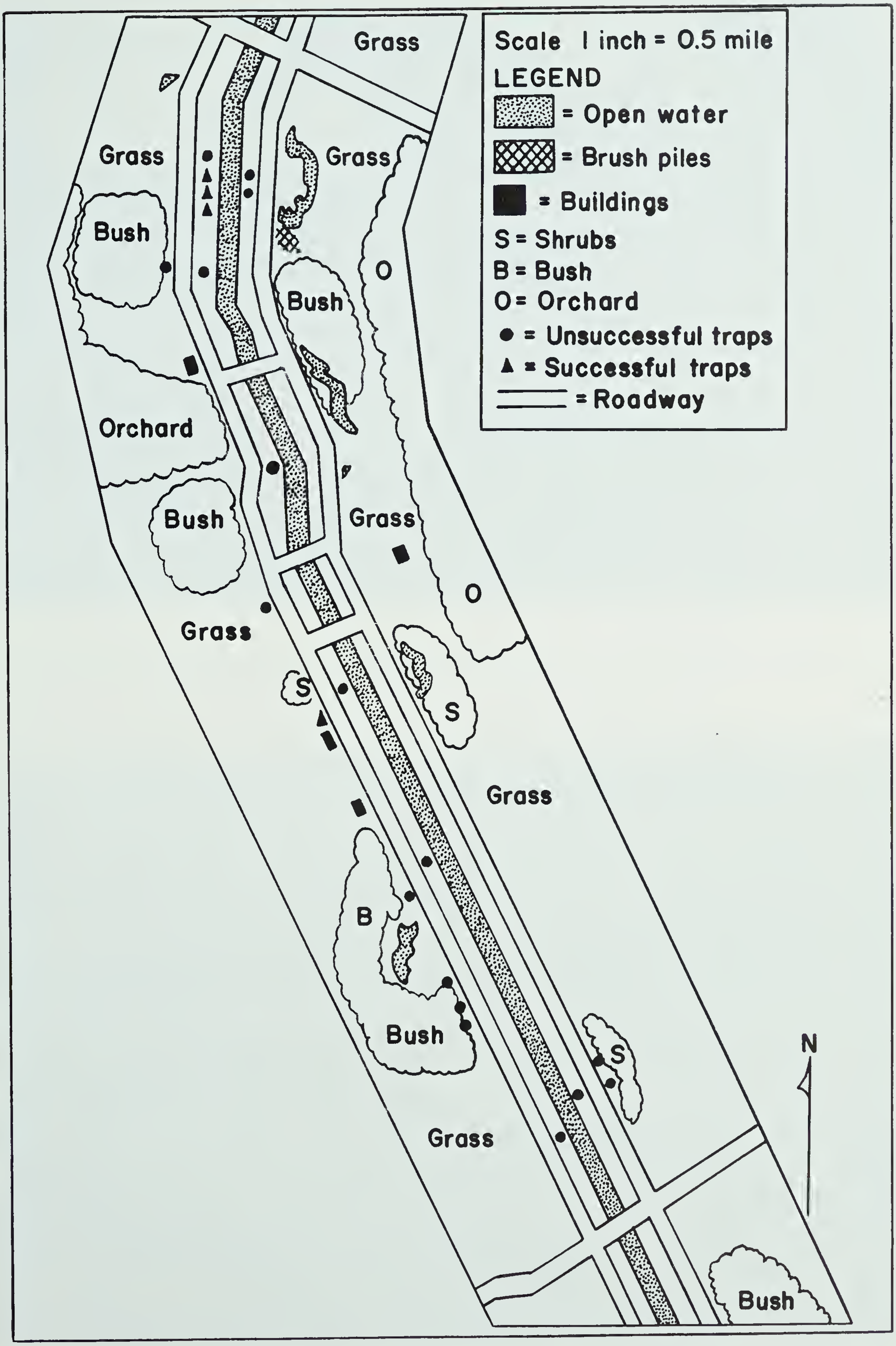
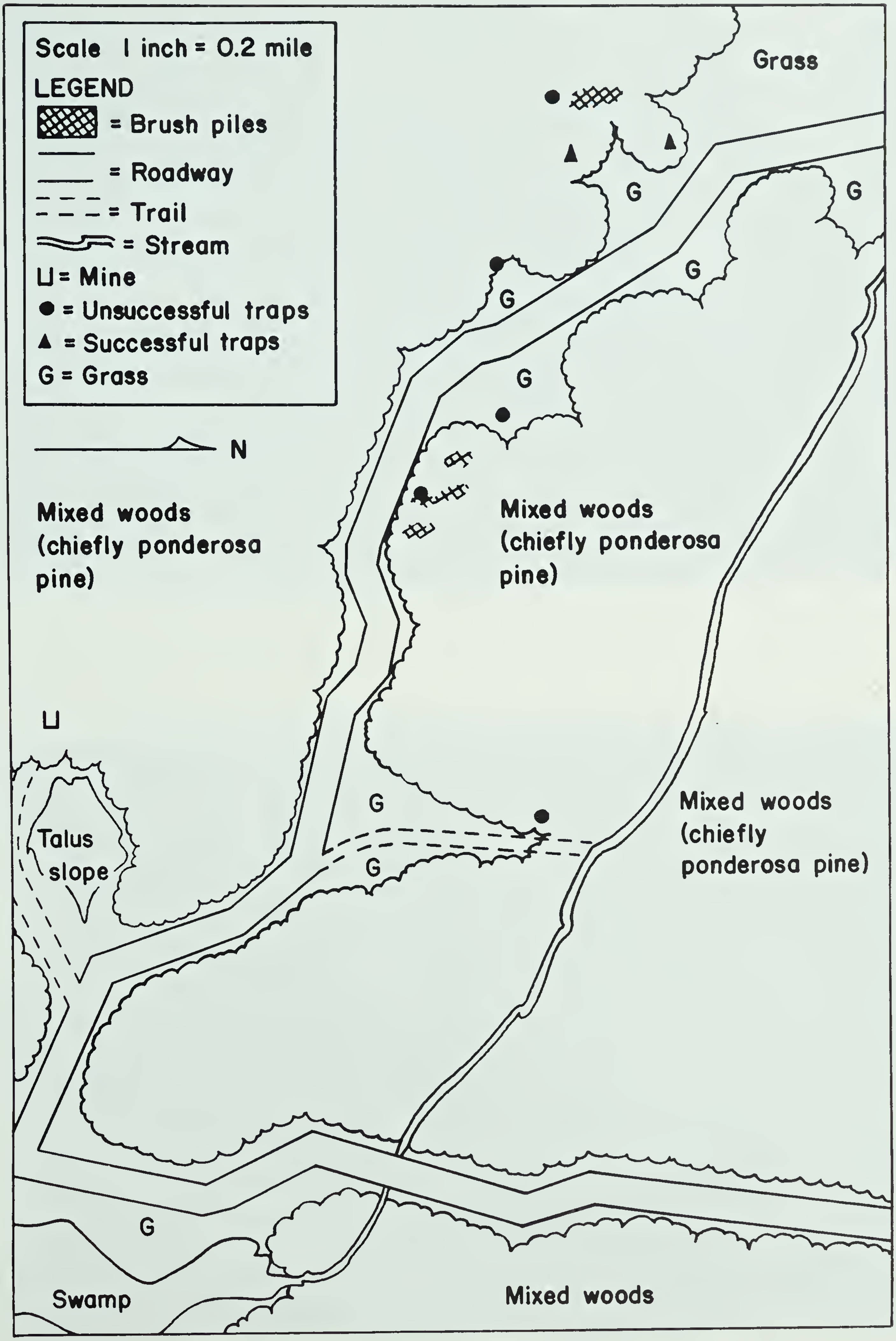

Scale l inch = 0.5 mile
LEGEND
= Open water
= Brush piles
= Buildings
S = Shrubs
B = Bush
O = Orchard
= Unsuccessful traps
= Successful traps
= Roadway
Grass
Grass
Grass
Bush
Bush
O
Orchard
Bush
Grass
O
Grass
S
S
Grass
B
Bush
S
Grass
Bush
N

Fig. 10. Brush piles on the north end (east side of levee) of study area 3.

Fig. 11. West side of levee, near the north end of study area 3.

Fig. 12. Map of vegetation types and trap locations on study area 4.



Scale 1 inch = 0.2 mile
LEGEND
= Brush piles
= Roadway
= Trail
= Stream
= Mine
= Unsuccessful traps
= Successful traps
G = Grass
N
Grass
G
Mixed woods (chiefly ponderosa pine)
Mixed woods (chiefly ponderosa pine)
Talus slope
Mixed woods (chiefly ponderosa pine)
Swamp
Mixed woods

Fig. 13. Open area at north-west corner of study area 4.

Fig. 14. Brush piles in study area 4.

RESULTS AND DISCUSSION

A total of 137 California quail were collected; 106 in the summer of 1965 and 31 in the summer of 1966. The raw data from each bird autopsied, giving sex, age, weight, capture data for each bird, the parasites found, and the amount of pesticide residues found, are tabulated in Appendix II. Table II gives the number of adult male, female and juvenal California quail collected from each area. All birds were autopsied for parasites; only adult females and juveniles were analyzed for pesticide residues. The number of samples that could be analyzed prevented doing all of the adult birds. Females rather than males were analyzed, as the preovulatory ovaries are known to concentrate pesticide residues, and these pesticide residues, via concentration in the ova, are passed on to the next generation. If the ovarian concentrations are high enough hatching success may be reduced (Genelly and Rudd, 1956).

Table II. Number of adult male, female and juvenal California quail collected from each study area during the summers of 1965 and 1966.*

Area	Year	Adult males	Adult females	Juveniles
1	1965	7	3	34
1	1966	4	5	3
2	1965	18	9	5
2	1966	1	1	0
3	1965	4	3	15
3	1966	5	2	10
4	1965	2	1	5
4	1966	0	0	0
Totals		41	24	72

* The discrepancy between the number of adult male and female quail collected from each area in 1965 and the number of pre-nesting adults in each area (Table XXIV) is accounted for by the immigration of individual quail into these areas from the immediate surrounding areas during the collecting regime.

Parasites

Two species of cestodes, *Rhabdometra odiosa* and *Choanotaenia infundibulum*, one species of nematode, *Acuaria spinosa*, two species of lice, *Goniodes stefani* and *Colinicola docophoroides*, one species of louse fly (Hippoboscidae), *Ornithomyia fringillina*, and one species of tick, *Haemaphysalis leporispalustris*, were collected from California quail during this study. The records of *C. infundibulum*, *A. spinosa*, and *O. fringillina* are apparently the first from California quail. The percentage of infected birds and the mean number of parasites per infected bird for each parasite are given in Table III.

Lagopoecus gambeli, previously collected from California quail by Spencer (1957) was not found in this study, nor were mites.

Rhabdometra odiosa (Leidy, 1887) Jones, 1929.

This parasite was collected from California quail from all four study areas. All mature specimens of this cestode were collected from the posterior part of the small intestine.

A scolex, mature segment, and gravid proglottid of this species, drawn from specimens collected in this study, are shown in Fig. 15.

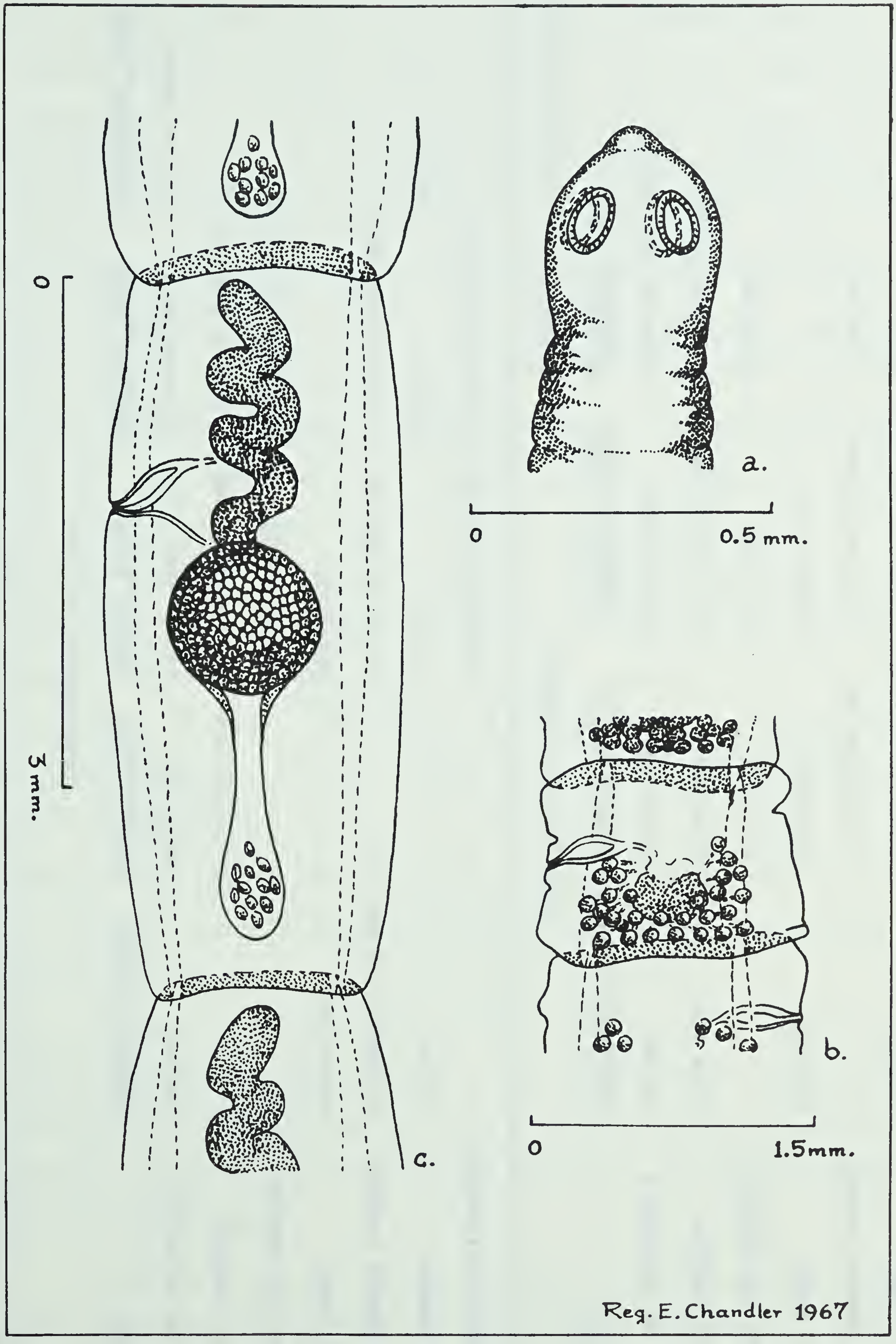
R. tomica, from Eurasian grouse, is very similar to *R. odiosa*. Table IV gives the morphological characteristics of the specimens examined from California quail and of *R. odiosa* and *R. tomica* from various published descriptions.

Jones (1929), while realizing the two species were morphologically similar, felt that they could be separated on the basis of range, as *R. tomica* was confined to Eurasia and

Table III. Parasite infection levels in adult and juvenal quail.

Parasite species	Per cent infected		Mean no./infected bird	
	Adults	Juveniles	Adults	Juveniles
Rhabdometra odiosa	53.8	45.8	13.5	22.4
Choanotaenia infundibulum	1.5	9.7	2	1.7
Acuaria spinosa	4.6	0	5	-
Goniodes stefani	1.5	2.8	-	-
Colinicola docophoroides	6.2	40.3	-	-
Ornithomyia fringillina	0	1.4	-	-
Haemaphysalis leporispalustris	0	1.4	-	-

Fig. 15. *Rhabdometra odiosa*. (a) scolex, (b) mature segment, (c) gravid segment.



0
3 mm.
a.
0
0.5 mm.
b.
0
1.5mm.
c.
Reg. E. Chandler 1967

Table IV. Morphological characteristics of *Rhabdometra odiosa* and *Rhabdometra tomica*.

	Rhabdometra odiosa				
Authority	Present study	Leidy, 1887	Jones, 1929	Swales, 1934	Krogsdale, 1950
Length of strobila	185 mm	20-50 mm	50 mm (max.)	270-400 mm	109 mm (max.)
Width of scolex	-	0.3-0.45 mm	0.255-0.400 mm	0.380-0.470 mm	-
Diameter of sucker	-	-	0.120-0.180 mm	0.178-0.256 mm	-
Genital pore	anterior	-	anterior	-	-
Cirrus pouch length	0.228-0.358 mm	-	0.165-0.300 mm	0.258-0.406 mm	-
Testis number	19-34	-	12-25	15-43	18-45
Onchosphere diameter	-	-	0.028-0.032 mm	0.028-0.030 mm	-

	Rhabdometra tomica			*Rhabdometra tomica kirikowi*
Authority	Southwell, 1930	Jones, 1929	Kasimov, 1956	Kasimov, 1956
Length of strobila	70 mm	60-70 mm	60-70 mm	219-238 mm (max.)
Width of scolex	0.54 mm	0.45 mm	0.45-0.54 mm	0.53-0.79 mm
Diameter of sucker	-	0.2 mm	0.2 mm	0.23 mm
Genital pore	anterior	anterior	anterior	-
Cirrus pouch length	-	0.32-0.36 mm	0.32-0.36 mm	0.56 mm
Testis number	20-30	20-30, or more	20-30, or more	39-60
Onchosphere diameter	-	0.037 mm	0.037 mm	0.033 mm

R. odiosa, at that time, was known only from the south-eastern United States. Swales (1939), who found sharp-tailed grouse (*Pedioecetes phasianellus*) from Quebec infected with *R. odiosa*, proposed, however, that *R. tomica* be considered a synonym of *R. odiosa* "in spite of the difference in the geographical distribution and hosts, which do not appear to be valid reasons for retaining *R. tomica* as a separate species in the face of the morphological data". As is evident from Table IV, *R. tomica* is nearly identical with *R. odiosa* and actually differs much less from this species than it does from *R. t. kirikowi*, a subspecies of *R. tomica* from Eurasia.

The hiatus in range between *R. odiosa* and *R. tomica* is now known to be less than 6,000 miles - from south-western Canada to east-central Asia. The host species for both *R. odiosa* and *R. tomica* are given in Table V. Even with the gap in distribution, and even though *R. odiosa* was not collected from a fairly large series of ptarmigan (*Lagopus* spp.) in Alaska (Babero, 1953), it appears that *R. tomica* and *R. odiosa* cannot be separated morphologically and thus should be considered conspecific.

Nothing is known about the life history of *R. odiosa*. I saw shed proglottids move towards a source of light. They did not move as fast nor as far as those of *Choanotaenia infundibulum*, though. This migration suggests that the intermediate host is not a dung-feeder.

Although *R. odiosa* was found from all four study areas, the infection levels were quite different (Table VI). The two areas with the highest infection levels are irrigated orchards,

Table V. Hosts of *Rhabdometra odiosa* and *Rhabdometra tomica*.

Rhabdometra odiosa

Host species	Locality collected	Reference
Sharp-tailed grouse (*Pedioecetes phasianellus*)	Quebec	Swales, 1934
Blue grouse (*Dendragapus obscurus*)	Washington	Schottelius, 1951
Bobwhite quail (*Colinus virginianus*)	S. E. United States	Jones, 1929
California quail (*Lophortyx californicus*)	Washington, S. British Columbia	Krogsdale, 1950, present study
Gambel's quail (*Lophortyx gambelii*)	Nevada	Gullion, 1957
Mountain quail (*Oreortyx pictus*)	Washington	Krogsdale, 1950

Rhabdometra tomica

Host species	Locality collected	Reference
Willow ptarmigan (*Lagopus lagopus*); Black grouse (*Lyrurus tetrix*); Hazel grouse (*Tetrastes bonasia*); Capercaillie (*Tetrao urogallus*); Black-billed capercaillie (*Tetrao parvirostris*)	Novosibirsk, Kemerovo, Mordovska, Kazakhstan, Ostrov Sakhalin and S. Ural mountains	Kasimov, 1956
Painted partridge (*Francolinus pictus*)	Calcutta Zoo, India	Southwell, 1930

Table VI. Extensity and intensity of infection with *Rhabdometra odiosa* in California quail, from each study area.

		Adults			
		Males	Females	Juveniles	Overall
Area 1	No. collected	10	8	37	55
	Extensity	80.0%	75.0%	75.7%	76.4%
	Mean intensity	3.4	10.7	23.0	16.9
	Range in intensity	1-7	1-27	1-69	1-69
Area 2	No. collected	19	11	5	35
	Extensity	68.4%	36.4%	60.0%	54.3%
	Mean intensity	19.7	21.5	16.7	19.6
	Range in intensity	2-56	3-50	5-25	2-56
Area 3	No. collected	9	5	25	39
	Extensity	22.2%	20.0%	4.0%	10.3%
	Mean intensity	1.5	?	?	1.5
	Range in intensity	1-2	?	?	1-2
Area 4	No. collected	2	1	5	8
	Extensity	50.0%	0.0%	0.0%	12.5%
	Mean intensity	1	-	-	1
	Range in intensity	1	-	-	1

the two areas with low infection levels are non-irrigated areas. Thus infection level appears to be correlated with moisture, as was suggested by Krogsdale (1950). There were, however, more quail in areas 1 and 2 (Table XX) and, as mentioned by Dogiel (1964), higher population densities of host species may lead to higher infection levels. However, the covey size and home range of the coveys from the four areas were essentially the same. California quail were seen only in restricted parts of areas 3 and 4, whereas they were observed in nearly all parts of areas 1 and 2. Thus population density, as such, does not appear to be the cause of the higher infection levels observed in areas 1 and 2.

The overall monthly infection rates in adult and juvenal quail are shown in Table VII. The monthly infection rates showed a similar pattern for each year taken separately. The differences in infection rates in adult quail may be due to moisture differences as, in both years, there was more rain in May and September than in midsummer. The infection levels in juvenal quail are due in part to differences in age, since very young quail are not often infected (Table VIII). However, even from any one area in any one month, juvenal quail taken showed a considerable spread in age. While there may be a general increase in infection level with age, the general increase in infection level from midsummer to fall is much more evident (compare Fig. 16, showing monthly infection levels with Fig. 17, showing infection levels according to age). The earlier and faster rise of the infection levels in the juveniles from areas 1 and 2 than in those from areas 3 and 4 suggest that

Table VII. Monthly infection rates of *Rhabdometra odiosa* in adult and juvenal California quail (both years, all areas).

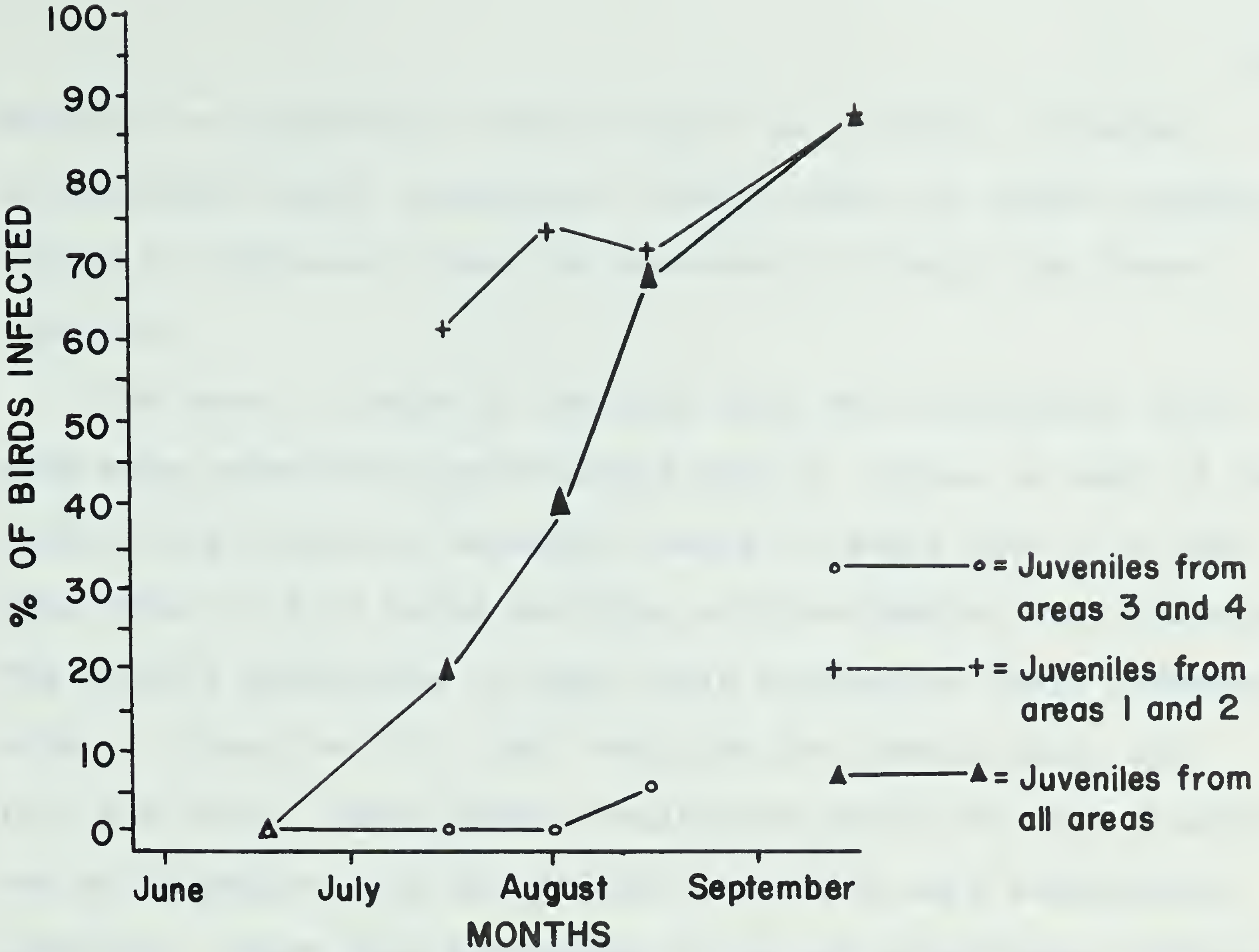
Month	No. examined	Per cent infected	Mean intensity	Range in intensity
Adults				
May	16	75.0	17.1	3-40
June	16	56.3	19.8	7-56
July	16	31.3	5.7	2-12
August	16	50.0	1.6	1-3
September	1	100	3	3
Juveniles				
June	2	0.0	-	-
July	15	20.0	16.7	5-25
August (first half)	37	40.5	14.2	1-42
August (second half)	10	70.0	32.3	9-62
September	8	85.0	20.1	10-69

Table VIII. Per cent of juvenal California quail, according to age, infected with *Rhabdometra odiosa*.

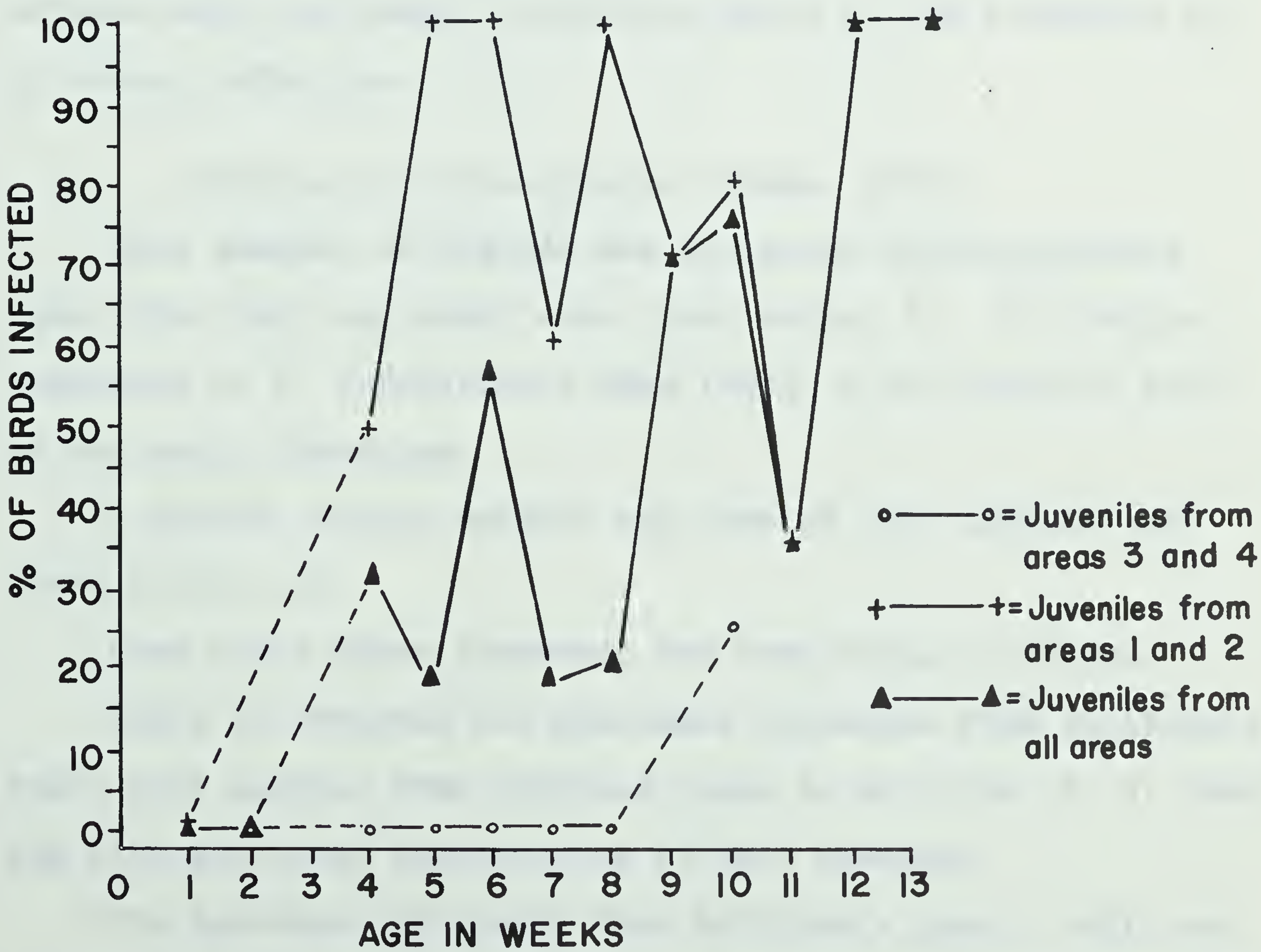
Age in weeks	Number examined	Per cent infected
1	1	0.0
2	1	0.0
3	0	-
4	3	33.3
5	11	18.2
6	7	57.1
7	16	18.2
8	5	20.0
9	7	71.4
10	15	80.0
11	3	33.3
12	2	100
13	1	100

Fig. 16. Monthly infection levels of juvenal California quail with *Rhabdometra odiosa*. Birds from areas 1 and 2 and from areas 3 and 4 are treated separately.

Fig. 17. Infection levels of juvenal California quail, according to age, with *Rhabdometra odiosa*. Birds from areas 1 and 2 and from areas 3 and 4 treated separately.



% OF BIRDS INFECTED
100
90
80
70
60
50
40
30
20
10
0
June
July
August
September
MONTHS
= Juveniles from areas 3 and 4
= Juveniles from areas 1 and 2
= Juveniles from all areas



% OF BIRDS INFECTED
100
90
80
70
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13
AGE IN WEEKS
= Juveniles from areas 3 and 4
= Juveniles from areas 1 and 2
= Juveniles from all areas

moisture or population density might be involved. However, as mentioned above, population density does not differ between coveys of different areas, so moisture is likely the factor involved.

The data in Table VI indicate that male California quail were more extensively parasitized with *R. odiosa* in each of the study areas (the only exception being in study area 1 in 1966 when three of four males and four of five females were infected). The overall percentage of adult male California quail infected with *R. odiosa* was 69.4 per cent; that for female quail was 44.0 per cent. Since female California quail eat more insects one would expect that the females should be more extensively infected. There does not appear to be any significant difference between male and female California quail in the intensity of *R. odiosa* infection.

Choanotaenia infundibulum (Bloch, 1779).

This species of cestode was collected from California quail from only one study area (area number 3). All mature specimens of *C. infundibulum* were found in the anterior part of the small intestine.

A scolex, mature segment and hook of this species are shown in Fig. 18.

When alive these tapeworms are waxy white in colour.

Table IX compares the specimens collected from California quail with several from chickens (lent to me by Dr. M. W. Reid) and with published descriptions of this species.

The specimens collected from California quail, while not typical for the species in all characteristics, fall within the

Fig. 18. *Choanotaenia infundibulum*.(a) scolex (from Kasimov, 1956), (b) mature proglottid (from Southwell, 1930), (c) hook (from Kasimov, 1956).

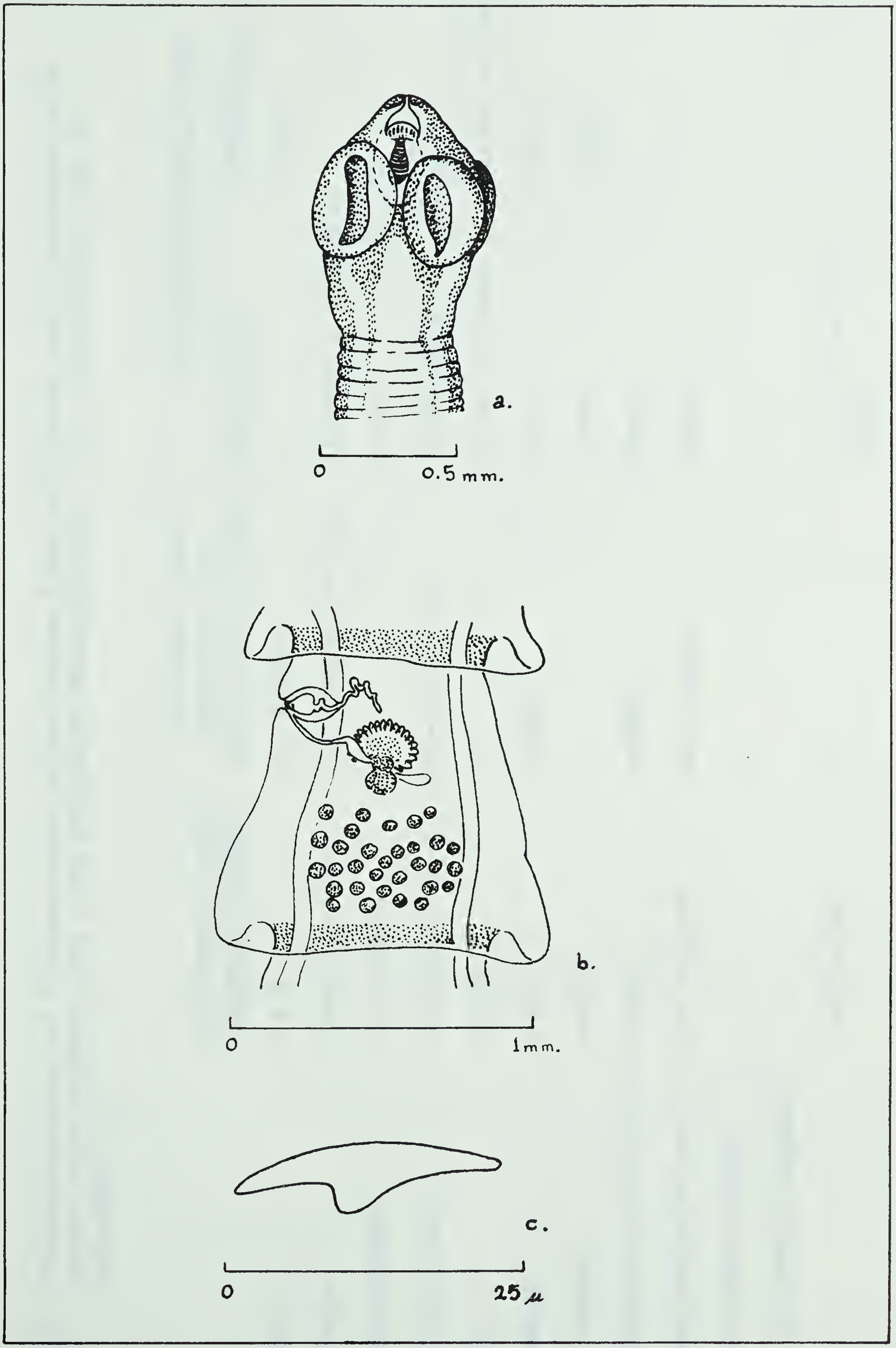

a.
0
0.5 mm.
b.
0
1 mm.
c.
0
25 μ

Table IX. Characteristics of *Choanotaenia infundibulum* from California quail compared with those from chickens and with published descriptions. All measurements are in microns.

	California quail (present study)	Chickens (from material lent by Dr. M. W. Reid)	Published descriptions: Reid, 1962	Published descriptions: Southwell, 1930
Hook size	18.3	18.3-20.0	-	20-30
Sucker size	300-315 x 360	255-300 x 195-210	180-250 x 135-175	-
Rostellum length	75-120(?)	?	65-90	-
Cirrus pouch size	150-180 x 75-85	90-105 x 75	75-95 long	-
Egg size	40-44	?	60-65 x 40-45	32-40 x 36-50
Hook number	14(?)	18-22	16-22	20-22
Testis number	40-50	?	25-60	25-30
Characteristics of cirrus	armed	armed	armed	-
Characteristics of sucker	not spined	not spined	spined	-
Ratio of cirrus pouch length to gravid segment width	1:20-1:30	?	1:19 (from diagram)	-

Table IX. (cont.)

	Published descriptions (as given in Matevosian, 1963)			
	Krabbe, 1869	Ransom, 1905	Skrjabin, 1914	Skrjabin, 1917
Hook size	20-27	20-30	24	20-30
Sucker size	-	250	110-130	250
Rostellum length	-	-	-	-
Cirrus pouch size	-	-	136-175 x 100	75-90 long
Egg size	-	65 x 40-45	-	-
Hook number	16-20	16-20	16-18	16-20
Testis number	-	-	-	25-40
Characteristics of cirrus	-	armed	armed	armed
Characteristics of sucker	-	-	-	-
Ratio of cirrus pouch length to gravid segment width	-	-	-	-

limits of variation of *C. infundibulum* for most of the characteristics examined (Table IX). The larger sucker size could be due to differences in fixation and preparation. The spines on the suckers were probably accidently removed during preparation; such spines are easily lost. The low hook number can also be similarly explained. The hook size is the same as the smallest measured from specimens lent to me by Dr. M. W. Reid. The cirrus pouch length falls within the range given for this species by Skrjabin (1914), as given in Matevosian (1963). The cirrus pouch is extremely variable in shape, being either elongated (as in the specimens collected from California quail) or short and oval (Matevosian, 1963). Thus the specimens collected during this study are considered to be *C. infundibulum*.

C. infundibulum has been recorded from the following secondary hosts: the housefly (*Musca domestica*), three species of grasshoppers (*Dicromorpha viridis*, *Dixippus morosus* and *Melanoplus femurrubrum*), one species of termite (*Reticulotermes flavipes*), and numerous species of beetles from the following families: Scarabaeidae, Carabidae, Alleculidae, Staphylinidae, Ostomalidae, Tenebrionidae, Dermestidae, Curculionidae, and Dytiscidae (Reid, 1962).

This cestode has been reported from a wide variety of definitive hosts, most of them galliformes: prairie chicken (*Tympanuchus cupido*) (Edminster, 1954), hazel grouse (*Tetrastes bonasia*), black grouse (*Lyurus tetrix*), capercaillie (*Tetrao urogallus*), ruffed grouse, sharp-tailed grouse (Reid, 1962), barbary partridge (*Alectoris barbara*), red-legged partridge (*A. rufa*), common partridge (*Perdix perdix*), common quail

(*Coturnix coturnix*), pheasant, turkey (*Meleagris gallopava*), chicken (*Gallus gallus domesticus*), tufted guinea-fowl (*Numida meleagris*) (Kasimov, 1956), Chinese francolin (*Francolinus pintadeanus*), Indian peafowl (*Pavo cristatus*), lesser kestrel (*Falco naumani*)?, black kite (*Milvus migrans*), dipper (*Cinclus cinclus*), (Matevosian, 1963), pigeon (*Columbia* sp.), bustard (*Otis* sp.), carrion crow (*Corvus corone*), and sparrow (*Ammospiza* sp.) (Yamaguti, 1959).

The extensity and intensity of *C. infundibulum* in California quail from area 3 are given in Table X. It appears that there was a difference in the infection rate between the two years and that juveniles are more often infected than are adults. It also appears that California quail are not the major hosts of *C. infundibulum*. There is some chicken raising done near area number 3 and the chickens may be the source of infection. There is also a good pheasant population in this area; they may also form a source of infection, but no California quail from area number 2, where pheasants are also common, were infected with this cestode.

Acuaria spinosa Cram, 1927.

This nematode was taken only in 1965 from adult California quail from area 2. All were found under the horny lining of the gizzard.

The specimens collected from California quail agree in all respects with the description given by Cram (1927).

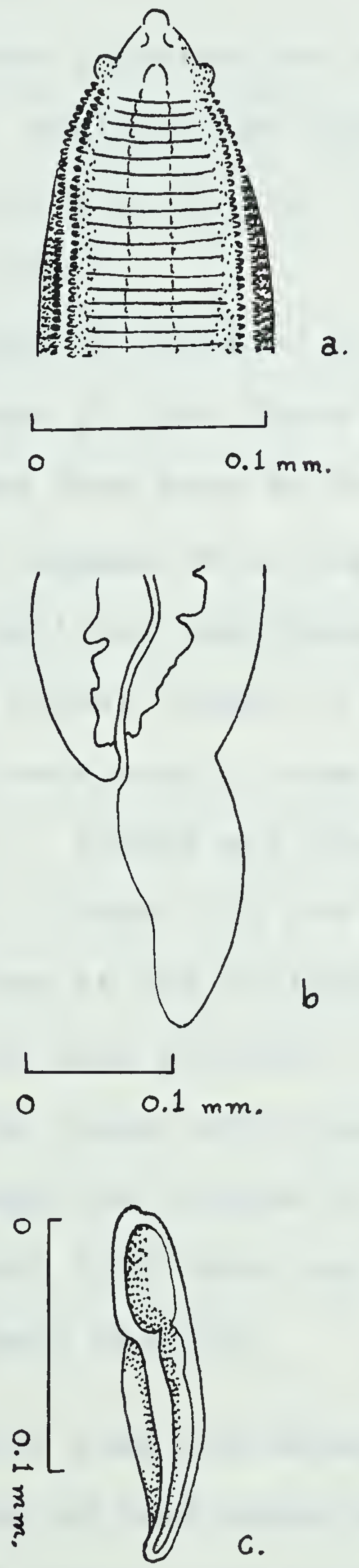
A head, tail of a female, and small spicule of a male are shown in Fig. 19.

The intermediate hosts of this species are grasshoppers

Table X. Extensity and intensity of *Choanotaenia infundibulum* in California quail from area 3.

	Number examined			Extensity (per cent)			Intensity (both years)	
	1965	1966	Both years	1965	1966	Both years	Mean	Range
Adults	7	7	14	14.3	0.0	7.1	2	-
Juveniles	15	10	25	40.0	10.0	28.0	1.7	1-3
All birds	22	17	39	31.8	5.9	20.5	1.8	1-3

Fig. 19. *Acuaria spinosa*. (a) head (b) tail of female (c) small spicule of male. (All figures from Cram, 1927.)


a.
0
0.1 mm.
b
0
0.1 mm.
0
0.1 mm.
c.

(*Melanoplus femurrubrum* and *M. differentialis*) (Yamaguti, 1961).

The definitive hosts recorded for this species are ruffed grouse, bobwhite quail, sharp-tailed grouse (Yamaguti, 1961), sage grouse (*Centrocercus urophasianus*) (Kasimov, 1956), and blue grouse (Bendell, 1955).

A. spinosa was found in three of 29 (10.4 per cent) adult birds collected from area 2; from three to seven (average five) nematodes were recovered from each of the infected birds. California quail do not appear to be the major hosts for this parasite. Bobwhite quail are considered to derive their infections from ruffed grouse (Cram, in Stoddard, 1931). Both ruffed and blue grouse were seen in area number 2, and may be the source of infection. Ruffed and blue grouse were also present in area number 4 (where the one ruffed grouse collected had *A. spinosa*), but none of the California quail collected there were infected with this parasite. However, few California quail occur in this area (none were present in 1966) and only eight were examined, thus the chances for finding infections with *A. spinosa* in quail from this area were too low to draw any conclusions from their absence.

Goniodes stefani Clay and Hopkins, 1955.

All three specimens of this louse were collected in 1965 from quail from areas 1 and 3. All of them were found infecting the nape region. They were determined by Dr. K. C. Emerson.

This louse has been reported from both California and Gambel's quail (*Lophortyx gambelii*) (Clay, 1940). It appears to be an

uncommon parasite in this region since only three California quail (one adult and two juveniles) were found infected.

Colinicola docophoroides (Piaget, 1880).

This species was collected from California quail from all study areas. All of the birds that were infected with lice had this species. One specimen was found on the nape, all the others were collected from the primary and secondary feathers of the wings. The intensity of infection was light in all of the infected birds.

A representative sample of specimens, showing extremes in variation, were all determined as this species by Dr. K. C. Emerson.

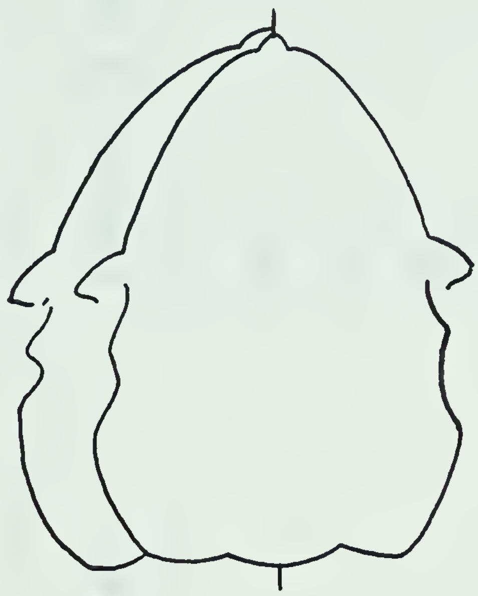
The variation noted in head shape is shown in Fig. 20a. Variations in the chaetotaxy of the posterior dorsal pterothorax and abdomen are given in Tables XI and XII.

The male genitalia, which are diagnostic for this species, are shown in Fig. 21.

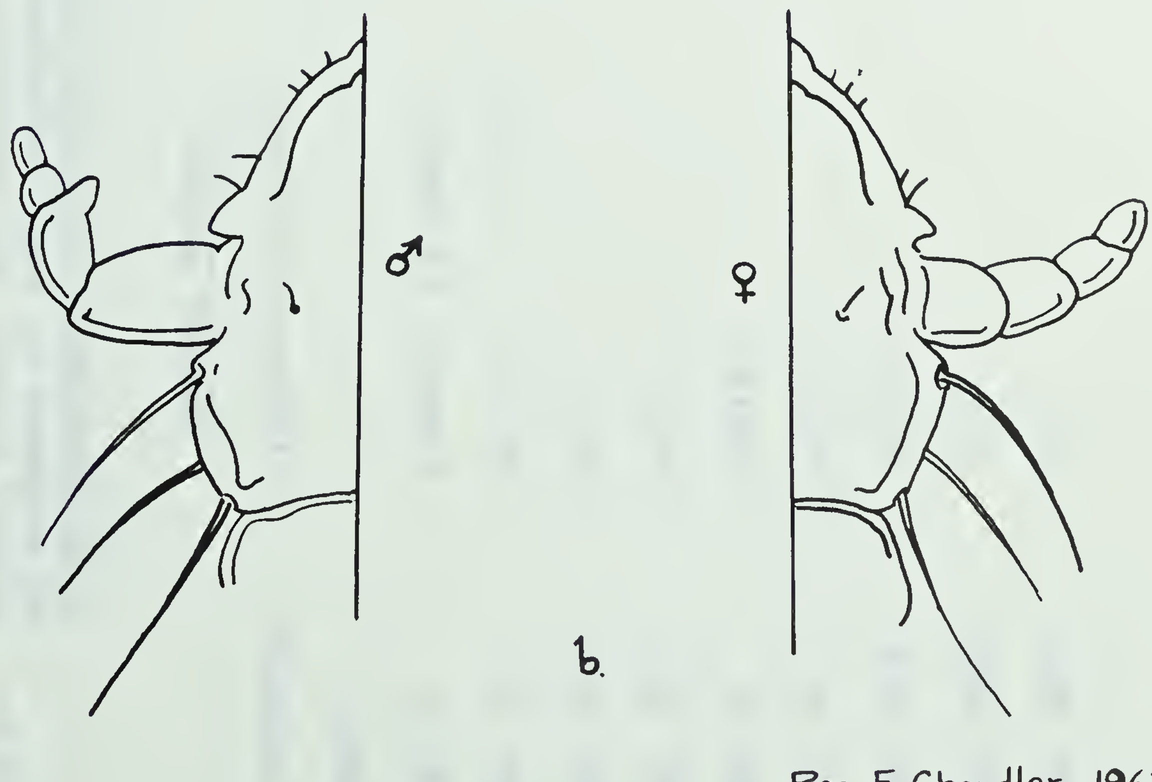
The female of this species is similar to the male, but the head may be somewhat more elongated and does not have segment I of the antennae enlarged nor segment II of the antennae with a projection on it as does the male (Fig. 20b). An adult female is shown in Fig. 22.

The percentage of birds infected with *C. docophoroides* from each of the study areas is given in Table XIII. The average infection level for adult California quail from all areas was 6.2 per cent; for juvenal quail the average infection level from all areas was 40.3 per cent. From Table XIII it is obvious that there is a difference between infection levels in the

Fig. 20. *Colinicola docophoroides*. (a) head of male showing variation in shape (b) head of male (left) and female (right).



a.



b.

Reg. E. Chandler 1967.

Table XI. Normal number and arrangement of hairs on pterothorax and dorsal surface of abdomen of male *Colinicola docophoroides* with extremes in variation from specimens collected during this study. Normal values from Caly (1938).

	Normal values	Extremes in variation	
Pterothorax	2,2,1,1. 1,1,2,2.	2,1,1,1,1,1. 1,1,1,1,1,2.	2,2,2,1. 1,2,2,2.
Abdomen			
Seg. I	2 ant., 12 post.	2 ant., 8 post.	2 ant., 12 post.
Seg. II	14	20	24
Seg. III	20	20	24
Seg. IV	20	20	24
Seg. V	16-18	16	20
Seg. VI	12	16	20
Seg. VII	8	10	10
Seg. VIII	4	4	4
Seg. IX	4	4	4

Table XII. Normal number and arrangement of hairs on pterothorax and dorsal surface of female *Colinicola docophoroides* with extremes in variation from specimens collected during this study. Normal values from Clay (1938).

	Normal values	Extremes in variation	
Pterothorax	2,1,1,1,1. 1,1,1,1,2.	2,1,1,1,1. 1,1,1,1,2.	2,2,1,3,1. 1,3,1,2,2.
Abdomen			
Seg. I	2 ant., 12 post.	2 ant., 8 post.	2 ant., 12 post.
Seg. II	18-22	16	22
Seg. III	18-22	16	22
Seg. IV	18-22	18	22
Seg. V	18-22	18	20
Seg. VI	12-14	14	18
Seg. VII	12-14	10	12
Seg. VIII	4	4	4
Seg. IX	2	2	2

Fig. 21. *Colinicola docophoroides*. Genitalia of male (x 300).

Fig. 22. *Colinicola docophoroides*. Adult female (x 20).

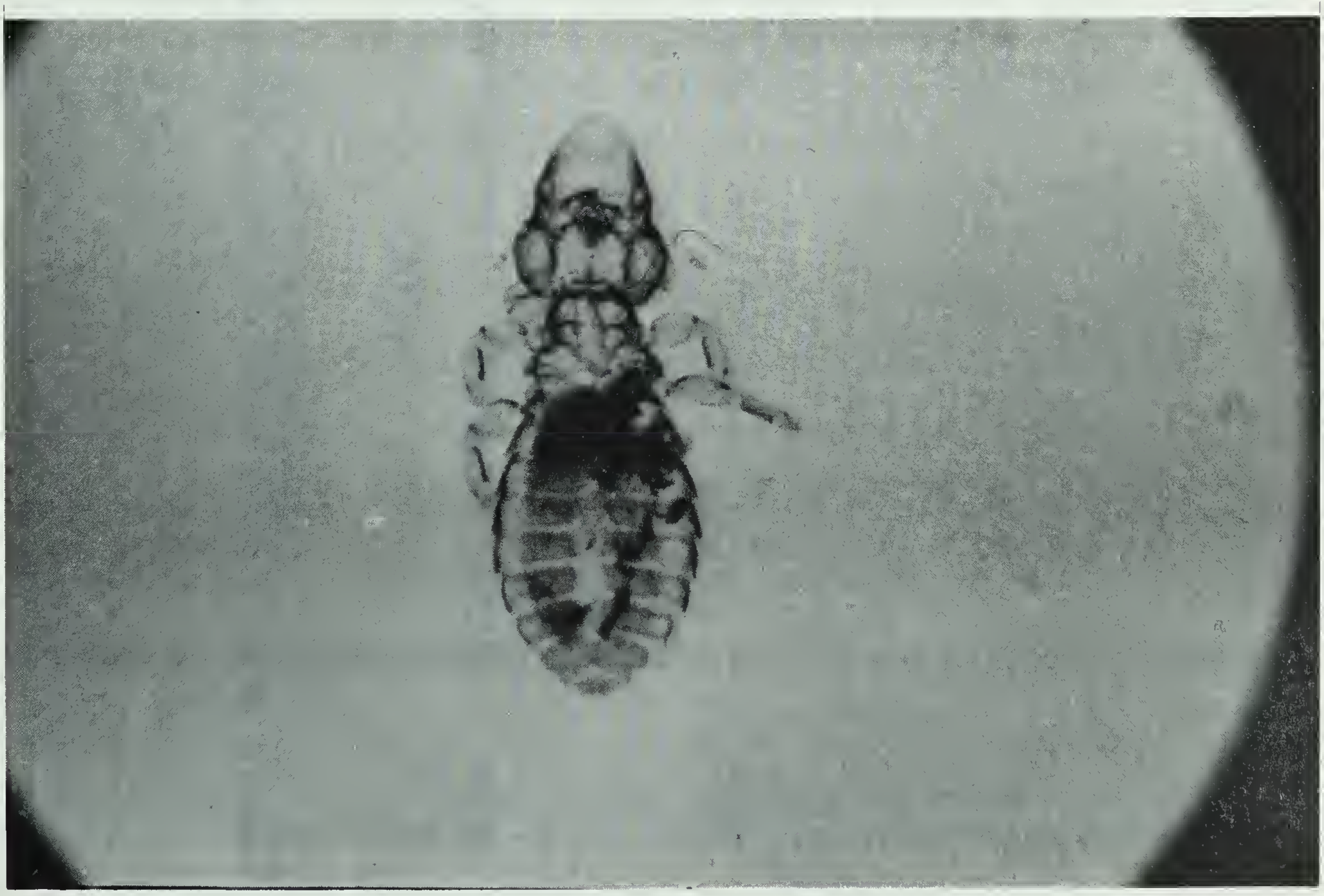


Table XIII. Percentage of adult and juvenal California quail infected with *Colinicola docophoroides*, from each study area.

	Adults		Juveniles	
Area	Number examined	Per cent infected	Number examined	Per cent infected
1	18	22.2	37	29.7
2	30	0.0	5	40.0
3	14	0.0	25	48.0
4	3	0.0	5	80.0

juveniles and the adults. Adult quail can rid themselves of lice by frequent dust bathing (Emlen and Glading, 1945); young juvenal quail do not dust bathe (Lewin, pers. comm.).

The apparent difference between the number of infected juveniles from different study areas could be explained by the presence of pesticides in the soil of areas 1 and 2. It has been recognized for a long time that DDT and certain other insecticides were useful against ectoparasites. The dusting of infected chickens with DDT to rid them of lice is a common practice. Young infested swifts (*Apus apus*) dusted with DDT were rid of all of their ectoparasites (Bannerman, 1955). Area 1 was the most heavily sprayed of all of the areas; area 2 was not sprayed in 1965 but had been sprayed on previous years; area 3 was about 1/4 mile from the nearest spraying; area 4 was not sprayed. Thus it appears that there is an inverse correlation between the amount of spraying in each area with the level of infection in juvenal quail in that area, which suggests that pesticides present in the orchard soil, which would be used for dust bathing, help rid the birds of lice.

It is not known why the adult California quail from area 1 (22.2 per cent) were the only ones infected with *C. docophoroides*.

There does not appear to be any significant difference in the monthly infection rates of adult quail during the summer months as is shown in Table XIV; in juvenal quail, however, there does appear to be an increase in the percentage of infected birds in the fall. There also appears to be a peak in the infection level of juvenal quail according to age (Table XV). The apparent decrease in the number of infected older juveniles

Table XIV. Monthly infection levels of *Colinicola docophoroides* for California quail.

Month	Number examined	Per cent infected
Adults		
May	16	6.3
June	16	6.3
July	16	0.0
August	16	6.3
September	1	100
Juveniles		
June	2	0.0
July	15	46.7
August	47	34.0
September	8	87.5

Table XV. Percentage of juvenal quail, according to age, infected with *Colinicola docophoroides*.

Age in weeks	Number of birds examined	Percentage of birds infected
1	1	0.0
2	1	0.0
3	0	-
4	3	66.7
5	11	54.5
6	7	85.7
7	16	62.5
8	5	40.0
9	7	0.0
10	15	20.0
11	3	0.0
12	2	50.0
13	1	0.0

(see Table XV) is likely due to their more frequent dust bathing.

Ornithomyia fringillina Curtis

Only one specimen of this hippoboscid fly was collected. It was secured from a juvenal quail from area number 4 in 1965.

The specimen collected agrees with the description by Bequaert (1954) in every detail, with the exception that the wing has more microtrichia than usual (see Fig. 23). The general appearance of this fly is shown in Fig. 24.

This species of louse fly is holarctic. It breeds on galliformes, certain genera of passeriformes, and piciformes; it has been recorded from a total of 107 North American species of birds (Bequaert, 1954).

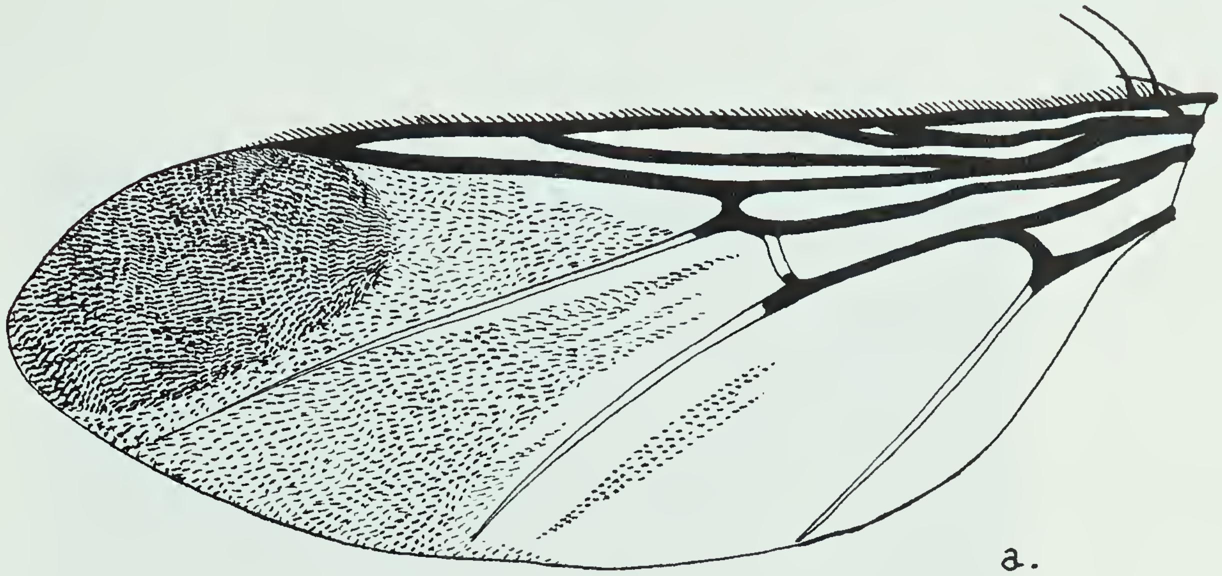
This is the first time that *O. fringillina* has been recorded from California quail, and, as the former shows a preference for a temperate climate (170 of 177 collecting localities were north of 36° N according to Bequaert, 1954), it may not be a common parasite within the normal range of California quail. Both blue and ruffed grouse (both recorded as hosts for *O. fringillina*) were found in study area number 4, where the single specimen of this fly was collected; these may have been the source of the infection.

Haemaphysalis leporispalustris (Packard, 1869).

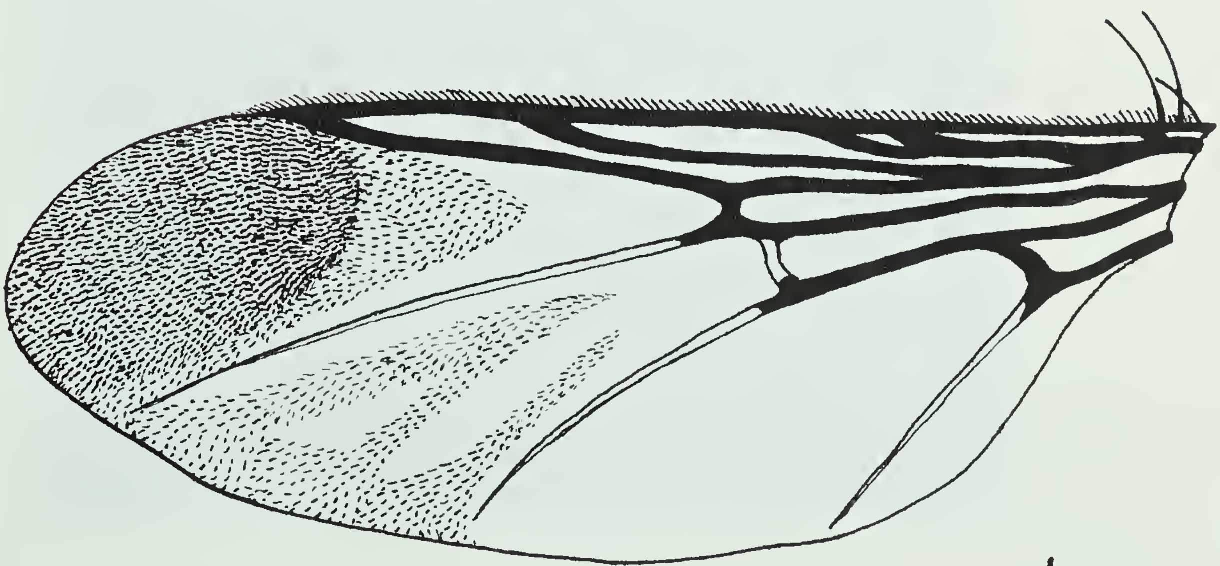
Only one specimen of this tick was collected which came from a juvenal California quail from area number 3 in 1965.

It agrees with the description of the nymph of this species, the form most often found infecting birds, in Nuttall

Fig. 23. Wing venation and arrangement of microtrichia in *Ornithomyia fringillina*. (a) From specimen collected from juvenal California quail (b) normal (from Bequaert, 1954).



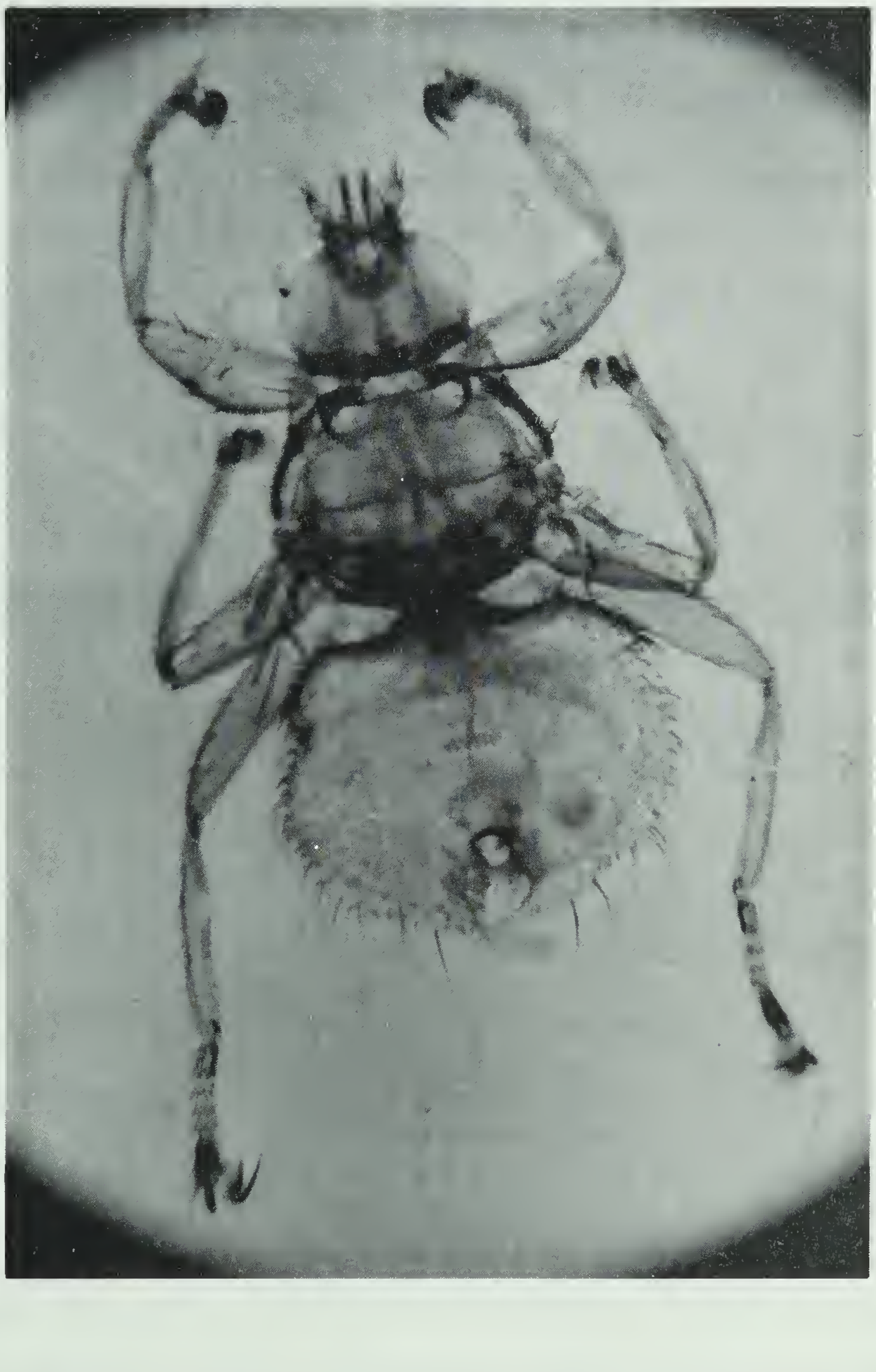
a.



b.

Reg. E. Chandler 1967

Fig. 24. *Ornithomyia fringillina.* Female. In this specimen the wings have been removed (x 10).



and Warburton (1915).

Adults of this species are normally a parasite of rabbits (*Sylvilagus* spp.) and hares (*Lepus* spp.). The nymphs are commonly found on ground inhabiting birds such as grouse and quail and have been found infesting California quail in other areas.

Effects of Parasites on California Quail

In general California quail are relatively free from serious disease or parasitic infections. Few natural deaths have been confirmed as being caused by disease or parasites; no serious epidemics have been observed (Edminster, 1954). No dead or dying California quail were noticed during the present study. All of the birds collected were apparently in good to excellent condition.

There is little or no difference in the emaciation indices of California quail with *R. odiosa* as compared to those without this parasite (Table XVI). In four birds a slight haemorrhagic area in the small intestine was noticed at or near the site of attachment of the scolices of this tapeworm. Other than this, there were no signs of *R. odiosa* having any detrimental effect on California quail during the summer months in the Okanagan Valley.

None of the birds infected with *Choanotaenia infundibulum* showed any haemorrhagic areas or lesions in the small intestine at the site of attachment of this cestode, nor did they show reduced emaciation indices (Table XVI). It appears that *C. infundibulum* has little or no effect on California quail from the Okanagan Valley during the summer months.

There was no visible inflammation of the gizzards of the three California quail infected with *Aouaria spinosa* as has been reported from bobwhite quail (Cram, in Stoddard, 1931). All of the infected birds were collected from area 2 in 1965. The average emaciation index for the uninfected birds from this area was 100.0 (range - 88 to 120); the average emaciation index

Table XVI. Emaciation indices of California quail infected and not infected with *Rhabdometra odiosa*, *Choanotaenia infundibulum*, and lice.

		Emaciation index		
	No. examined	Average	Standard deviation	Range
Adults				
With *R. odiosa*	32	97.7	9.04	80-119
Without *R. odiosa*	24	96.3	11.55	75-120
With *C. infundibulum*	1	86	-	-
Without *C. infundibulum*	10	93.5	12.45	75-109
With lice	4	102.5	5.77	97-112
Without lice	51	96.7	10.30	75-120
Juveniles				
With *R. odiosa*	31	91.1	9.89	73-112
Without *R. odiosa*	30	88.7	10.92	56-114
With *C. infundibulum*	7	87.9	6.33	78-100
Without *C. infundibulum*	13	90.0	11.96	75-114
With lice	27	83.8	11.68	56-114
Without lice	34	87.7	9.96	73-112

of the three infected birds was 109.3 (range - 108 to 110). It appears that *A. spinosa* has little effect on the California quail of the Okanagan Valley in the summer. However, in bobwhite quail, heavy infections of this parasite may cause considerable harm (Cram, in Stoddard, 1931). Thus this parasite may be potentially harmful to the California quail in British Columbia.

No heavy infestations of lice (*Goniodes stefani* and *Colinicola docophoroides*) were noticed among the birds collected. The average emaciation indices of infected California quail do not appear to be reduced (Table XVI). These two species of lice have no apparent effect on the Okanagan Valley California quail during the summer.

Only one specimen of *Ornithomyia fringillina* was collected, suggesting that this louse fly is only of casual occurrence on California quail in the Okanagan Valley. This species may be capable of transmitting the pathogenic blood protozoan *Haemoproteus lophortyx*, as are several other species of louse flies. Under field conditions only moderate or heavy infections of *H. lophortyx* would be noticed (O'Roke, 1932). Birds so infected would be emaciated, weakened and anemic (O'Roke, 1932) and would probably show an enlarged black spleen and pigmented liver (O'Roke, 1928). Specimen C-40, from area 4, where *O. fringillina* was collected,was somewhat emaciated (the emaciation index was 56) but did not show any of the other symptoms; none of the other birds showed any of these symptoms. Unfortunately no blood smears were taken. Further work on the incidence and possible importance of *H. lophortyx* should be undertaken in

British Columbia.

While *Haemaphysalis leporispalustris* is a normal parasite of California quail, and heavy infestations on these birds have been reported in California (Bishopp and Trembley, 1945), only one specimen of this tick was collected during the present study, even though it is considered to be the most abundant tick in Canada (Hearle, 1938). The normal hosts of the adult ticks are either rabbits or hares, none of which are common in the quail habitats studied. The white-tailed jackrabbit (*Lepus townsendi*) is found in British Columbia only in the non-irrigated areas near Osoyoos (Cowan and Guiguet, 1965); none are found on or near any of the study areas selected. The snowshoe hare (*Lepus americanus*) does not normally occur in the cultivated areas of the valley (Cowan and Guiguet, 1965). Several Rocky Mountain cottontails (*Sylvilagus nuttalli*) were seen in the area where the single specimen of *H. leporispalustris* was collected. These were probably the source of infection for these quail. These rabbits (the only species occurring in this region) are scarce in the southern interior of British Columbia (Cowan and Guiguet, 1965).

H. leporispalustris is not likely to have any detrimental effect on California quail in the Okanagan Valley. It is, however, a potentially serious parasite of these birds, as it is capable of transmitting tularemia which can cause the death of gallinaceous birds (Hearle, 1938). Heavy infestations on young bobwhite quail have caused emaciation in the birds (Bishopp and Trembley, 1945).

Other species of helminths or ectoparasites may infect

California quail; those found in a wide range of North American gallinaceous hosts would be the most likely. Some of these, such as other louse flies or certain species of *Raillietina*, could conceivably have a detrimental effect on California quail. However, the parasites that are most likely to harm these birds, such as blood parasites (especially *Haemoproteus lophortyx* and *Lophortofilaria californiensis*) and intestinal protozoa (such as coccidia), were not investigated in this study.

Pesticide Residues

A total of 105 tissue or egg samples were sent for pesticide analyses; 78 of these were collected during the summer of 1965, 27 during the summer of 1966. The numbers of samples from each area, for each year, are summarized in Table XVII. The report from the Ontario Research Foundation dealing with the residues found in the 1966 samples has not been received as yet.

Of the pesticides for which analyses were made, methoxychlor residues were not found; lindane and endrin residues were found in one bird each; and dieldrin, heptachlor, heptachlor epoxide, DDT, DDD, and DDE were present in most of the birds analyzed.

All residue analyses were done on brain tissue, unless otherwise noted. DDT levels in the brain tissue and liver tissue of the closely related common quail (*Coturnix coturnix*) were found to be quite similar (Table XVIII) in a recent study by Boykins (1967). The average and actual residue values of DDT, DDE, and dieldrin in brain, liver, and breast muscle tissue of three pheasants that were analyzed by the Ontario Research Foundation (report ORF 65-4, 1965) are given in Table XIX. From this table it appears that DDT and DDE may be accumulated to a greater extent in brain tissue than in breast muscle tissue. Dieldrin may be accumulated in breast muscle tissue to a slightly greater extent than in brain tissue. In nearly all cases liver tissue accumulated more pesticide residues than did either brain or breast muscle tissue. These values suggest that, with the possible exception of dieldrin,

Table XVII. California quail samples submitted for analysis of pesticide residues.

Sample type	Area 1 1965	Area 1 1966	Area 2 1965	Area 2 1966	Area 3 1965	Area 3 1966	Area 4 1965	Area 4 1966
Adult females	3	5	9	1	3	2	1	0
Juveniles	34	3	5	0	13	10	5	0
Ovaries and eggs	0	6	6	0	0	0	0	0

Table XVIII. DDT levels in micrograms of DDT/gram of tissue in brain and liver tissue of common quail (*Coturnix coturnix*), as reported in Boykins (1967). Group I fed treated earthworms only, group II fed treated earthworms plus chick starter.

	Group I		Group II	
	Brain tissue	Liver tissue	Brain tissue	Liver tissue
	38	37	0	5
	32	44	0	0
	41	47	6	8
	44	31	0	0
	48	43	4	7
	51	42	10	16
	44	38	11	14
	51	57	18	10
			0	3
Average	43.6	44.8	5.6	6.3

Table XIX. Pesticide residues in parts per million in brain, liver, and breast muscle tissue of pheasants (from Ontario Research Foundation Report ORF 65-4).

	DDE	DDT	Dieldrin
Specimen 1			
Brain	0.051	-	-
Liver	0.145	-	0.005
Breast muscle	0.005	0.005	0.005
Specimen 2			
Brain	0.274	0.417	0.005
Liver	0.350	0.456	0.074
Breast muscle	0.033	0.005	0.005
Specimen 3			
Brain	0	0.005	0.005
Liver	0.085	0.260	0.037
Breast muscle	0.028	-	0.013
Average			
Brain	0.108	0.144	0.003
Liver	0.520	0.289	0.039
Breast muscle	0.022	0.003	0.008

the values obtained from the brain tissue of California quail, although somewhat low, are good indications of the average pesticide residue values for the entire bird. No data were available on tissue storage of heptachlor in birds, but as it is also a chlorinated hydrocarbon that is accumulated in fatty tissue, it is assumed that it would show a pattern similar to the others. As all of these pesticides act mainly on the nervous tissue, the values reported here may be more meaningful than those given for other tissues.

Pesticide residues were found in all California quail analyzed from study 1, 2, and 3. Only two birds out of the six analyzed from area 4 showed traces of pesticide residues. Thus, area 4 can serve as a control area for investigating the effects of pesticides (with some limitations, as this area is, at best, marginal for California quail).

The pesticide residues found in each bird analyzed are given in Appendix II. In all cases the residue values are low. The average monthly and the overall average residue values found in adult female and juvenal California quail from each area for 1965 are tabulated in Tables XX and XXII. All residue values are reported in parts per million. For each pesticide the average residue level was below 0.6 p.p.m. for each study area, and, in most cases,was below 0.3 p.p.m. The total pesticide residue values are reported as equivalents of DDT, on a molecular weight basis, in parts per million. In all cases the average total residue level found in the brain tissue was below 1.3 p.p.m. and, except for the adult females collected from area 1, was below 0.8 p.p.m. In most cases the average

Table XX. Average pesticide levels in parts per million from the brain tissue of adult female California quail. Total residue values are recorded as equivalents of DDT in parts per million. No methoxychlor or lindane was found in any of the specimens analyzed.

Area	Month	No. of birds	Heptachlor	Heptachlor epoxide	Dieldrin	DDE	DDD	DDT	Endrin	Total residue
1	Aug.	3	0.338	0	0.068	0.519	0.038	0.261	0	1.221
2	May	2	0.085	0	0	0.215	0	0.247	0	0.540
2	June	2	0	0	0	0.509	0.162	0.148	0	0.711
2	July	3	0.153	0.002	0	0.510	0.022	0	0	0.677
2	Overall	7	0.107	0.001	0	0.425	0.056	0.113	0	0.647
3	Aug.	1	0.131	0.085	0.094	0.005	0	0.161	0.005	0.503
4	Aug.	1	0.005	0	0	0	0	0	0	0.005

Table XXI. Average pesticide levels in parts per million from California quail breast muscle, egg, and ovary tissue. Total residue values recorded as equivalents of DDT in parts per million. No endrin or methoxychlor was found in any of the specimens analyzed.

Area	Sample No.	Sample Type	Heptachlor	Heptachlor epoxide	Dieldrin	DDE	DDD	DDT	Lindane	Total residue
2	5	Ovary	0	0	0.389	1.859	0.089	0.558	0	2.340
2	1	Egg	0	0	0.465	2.88	0.136	0.573	0	3.783
Adult females										
2	2	Muscle	0	0	0.024	0.020	0.020	0.005	0	0.065
3	1	Muscle	0.012	0.026	0.010	0.061	0.044	0.129	0.100	0.359
Juveniles										
1	1	Muscle	0.012	0	0	0.040	0.041	0.040	0	0.126
3	1	Muscle	0	0	0	0.047	0	0	0	0.042

Table XXII. Average pesticide levels in parts per million from the brain tissue of juvenal California quail. Total residue levels are recorded as equivalents of DDT in parts per million. No lindane, endrin, or methoxychlor was found in any of the specimens analyzed.

Area	Month	No. of birds	Heptachlor	Heptachlor epoxide	Dieldrin	DDE	DDD	DDT	Total residue
1	Aug.	25	0.073	0.022	0.033	0.262	0.004	0.171	0.548
1	Sept.	7	0.120	0.075	0.009	0.211	0.001	0.090	0.497
1	Overall	32	0.085	0.034	0.028	0.251	0.004	0.153	0.537
2	July	5	0.099	0	0.002	0.407	0.001	0.003	0.477
3	July	3	0.105	0.014	0.035	0.053	0.109	0.045	0.353
3	Aug.	9	0.031	0	0.001	0.045	0.038	0.001	0.108
3	Overall	12	0.044	0.003	0.009	0.047	0.056	0.012	0.169
4	July	4	0	0.001	0	0	0	0	0.001
4	Aug.	1	0	0	0	0	0	0	0
4	Overall	5	0	0.001	0	0	0	0	0.001

total pesticide residue was below 0.5 p.p.m. The highest total residue from an individual bird was 1.8 p.p.m. In all cases the average total residue level in juveniles from each sprayed area was lower than those from adult females from the corresponding area.

The average residue levels for the ovaries and the single egg collected in 1965 are given in Table XXI. The average residue level is 2.5 p.p.m. The highest total residue level from a single ovary with preovulatory follicles was 5.4 p.p.m. (Appendix II). In all cases the residue levels were higher in the ovaries than in the birds from which they were taken. In most cases the ovaries had three times as much pesticide residues as did the corresponding brain tissue.

While a comparison between the different areas is difficult, as the samples were not taken from all areas at the same time, it does appear that the total residue levels in California quail from area number 3 are somewhat lower than those from areas 1 and 2. California quail collected from area 1 also appeared to have a higher total residue level than did those from area 2. This likely reflects the spraying differences in these two areas in 1965 as noted in the methods section.

DDT was applied to area 1 in 1965 and 1966 at the rate of 12 lbs of 50 per cent wettable powder per acre (R. Sparke, in letter). Only one application was made each year. The California quail collected from this area in 1965 had DDT residue values from 0.0 to 0.814 p.p.m. The average DDT residue value for adult females from this area in 1965 was 0.261 p.p.m.; the average DDT residue value for juveniles was 0.153 p.p.m.

In area 2 there appears to be a gradual decrease in DDT residue levels from May to July with a corresponding increase in DDD and DDE residue levels from May to June. As DDD and DDE are breakdown products of DDT, this suggests breakdown of DDT in the tissues or environment without replacement of the DDT, and probably reflects the lack of spraying in this area in 1965. There do not appear to be any significant differences in pesticide residues from month to month for the other areas.

Effects of Pesticides on California Quail

There was no evidence of mortality due to pesticides in the orchards during the present study. No dead or dying birds were seen in any of the study areas; all birds observed behaved normally. McEwan and Brown (1966) found that sharp-tailed grouse fed dieldrin, if given a lethal dosage, would behave abnormally for as much as several days before dying. Any widespread or significant mortality among the quail would probably have been preceded by a marked change in the behavior of certain individual birds. The California quail from each study area were under observation nearly every day, but no abnormal behavior was noticed.

Stickel, Hayne, and Stickel (1965), among others, have reported that birds containing sublethal doses of pesticides in their tissues, if starved, show pesticide poisoning symptoms before dying. Therefore, during the summer of 1966, three juvenal quail, 4 to 6 weeks old, collected from area 3, were starved to death to see if the pesticide residues in their tissues were high enough to cause any toxic effects. The average total residue level for juvenal quail from this area for the summer of 1965 was 0.2 p.p.m., with a range from 0.01 to 0.6 p.p.m., and these birds may have had a similar pesticide accumulation. None of the three birds showed any of the symptoms of chlorinated hydrocarbon poisoning, such as tremors, uncoordinated muscular activity, etc. (Rudd, 1964), before their death, 8 to 11 days later. The bodies of these three birds were among the samples sent for pesticide analyses, but for which no report has been received.

Dahlen and Haugen (1954), among others, have demonstrated that birds fed insecticides lose weight (due to a loss of appetite) and that the weight loss is generally more pronounced and of longer duration for insecticides administered at higher levels. In this study general body condition, which would reflect such a weight loss, was determined on each California quail collected by means of an emaciation index, as outlined in the methods section. The average emaciation indices for adult and juvenal quail from all areas, for both years, are given in Table XXIII. It is evident that the general condition, as reflected by emaciation indices, of California quail from the sprayed areas (areas 1, 2, and 3) was as good as those from the control area (area 4). The scatter plot of total pesticide residues against the emaciation indices of the birds analyzed is shown in Fig. 25a. The regression co-efficient obtained from this scatter plot is not statistically significant. Scatter plots of individual pesticides against emaciation indices are shown in Figs. 25-27. None of the regressions are significant.

Heptachlor residues in the brain tissue of California quail reached 0.554 p.p.m.; levels of heptachlor epoxide reached 0.194 p.p.m. In comparison, a recent study found that woodcock (*Philohela minor*) collected in the field had an average of 2.4 p.p.m. of heptachlor in their tissues, a level below that toxic to woodcock (Stickel, Hayne, and Stickel, 1965).

In a recent study done on sharp-tailed grouse, dieldrin was fed to captured birds which were then released and observed by radio telemetry. These birds were later collected by shooting. The tissues of these birds (combinations of 5 grams of each of

Table XXIII. Average emaciation indices of adult and juvenal California quail.

	Year	Number examined	Emaciation index: Mean±Standard deviation	Range
Adults				
Area 1	1965	8	97.4±6.03	91-112
	1966	9	91.7±7.01	80-100
Area 2	1965	23	100.4±9.48	87-120
	1966	1	94.0 -	-
Area 3	1965	5	95.0±11.18	83-109
	1966	6	91.0±10.25	75-106
Area 4	1965	3	103.7±15.17	83-109
	1966	0	- -	-
Juveniles				
Area 1	1965	34	93.0±8.88	73-112
	1966	3	83.3±2.62	79-86
Area 2	1965	2	84.0±9.00	75-93
	1966	0	- -	-
Area 3	1965	13	91.8±10.68	75-114
	1966	6	83.6±6.67	75-92
Area 4	1965	2	73.5±17.50	56-991
	1966	0	- -	-

Fig. 25. Scatter plots of pesticide residues in brain tissue versus emaciation indices of California quail.

(a) Total pesticide residues. All values are recorded as equivalents of DDT in parts per million.

(b) Heptachlor residues.

(c) Heptachlor epoxide residues.

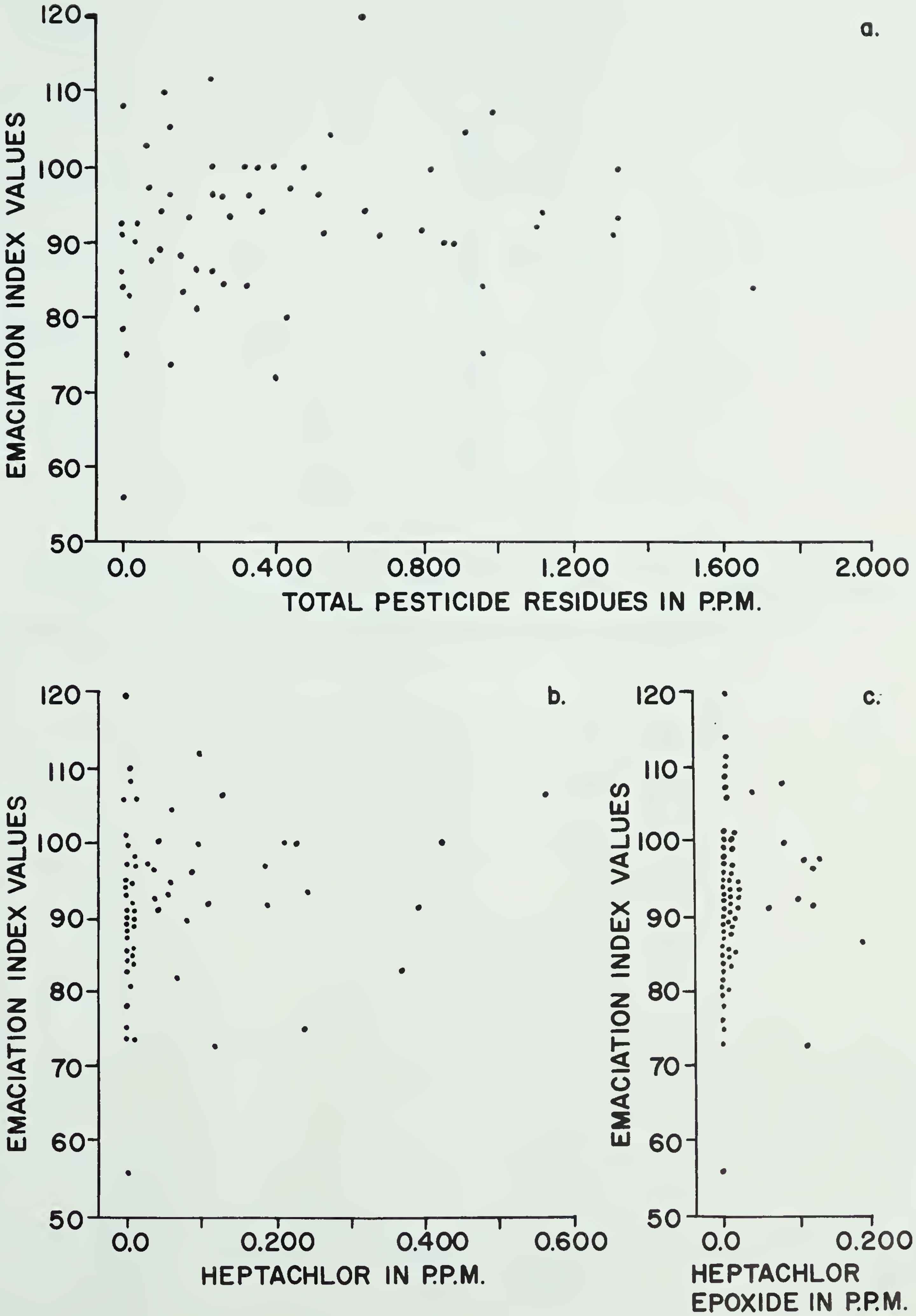

a.
EMACIATION INDEX VALUES
TOTAL PESTICIDE RESIDUES IN P.P.M.
b.
EMACIATION INDEX VALUES
HEPTACHLOR IN P.P.M.
c.
EMACIATION INDEX VALUES
HEPTACHLOR EPOXIDE IN P.P.M.

Fig. 26. Scatter plots of pesticide residues of brain tissue versus emaciation indices of California quail.

(a) Dieldrin residues.

(b) DDT residues.

(c) DDD residues.

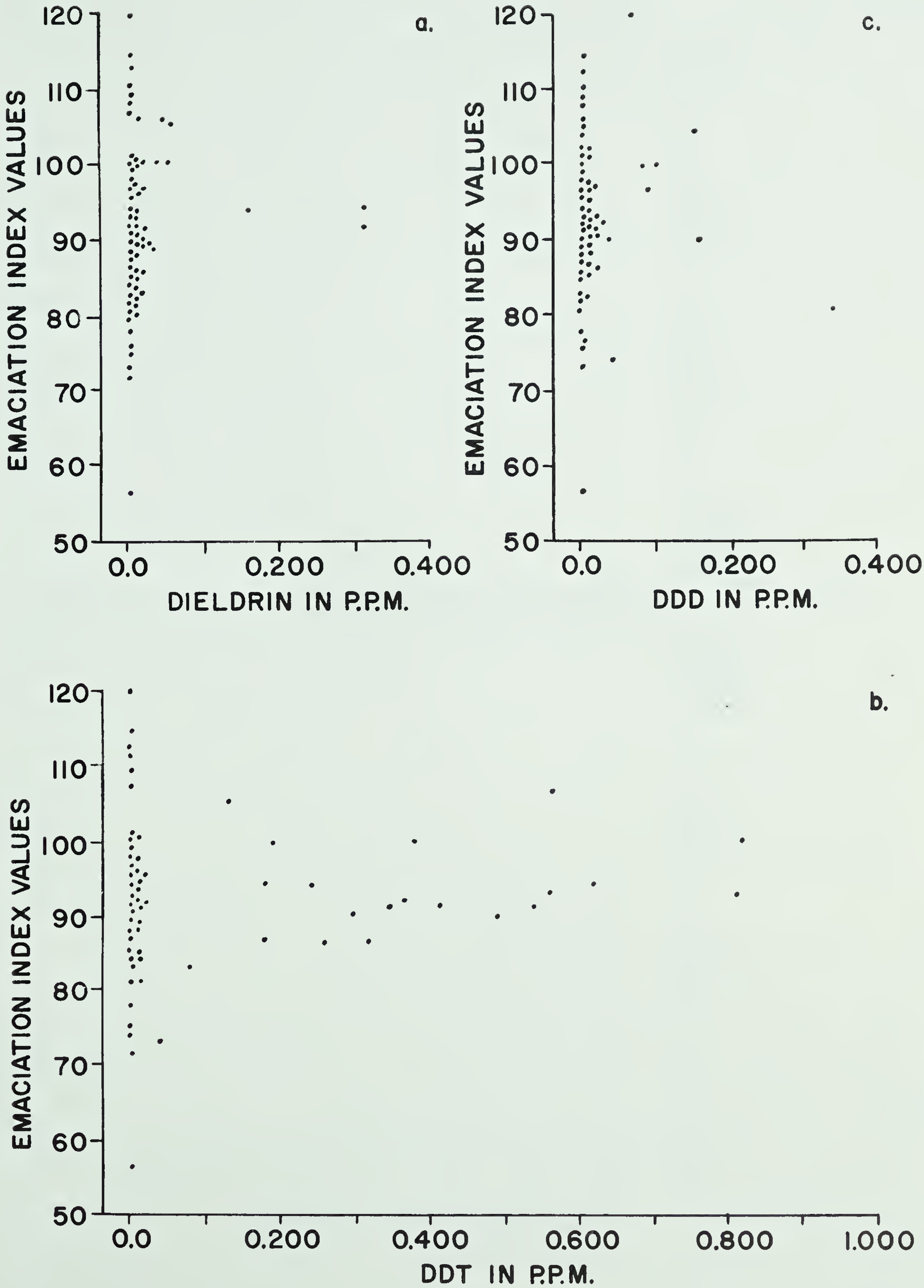
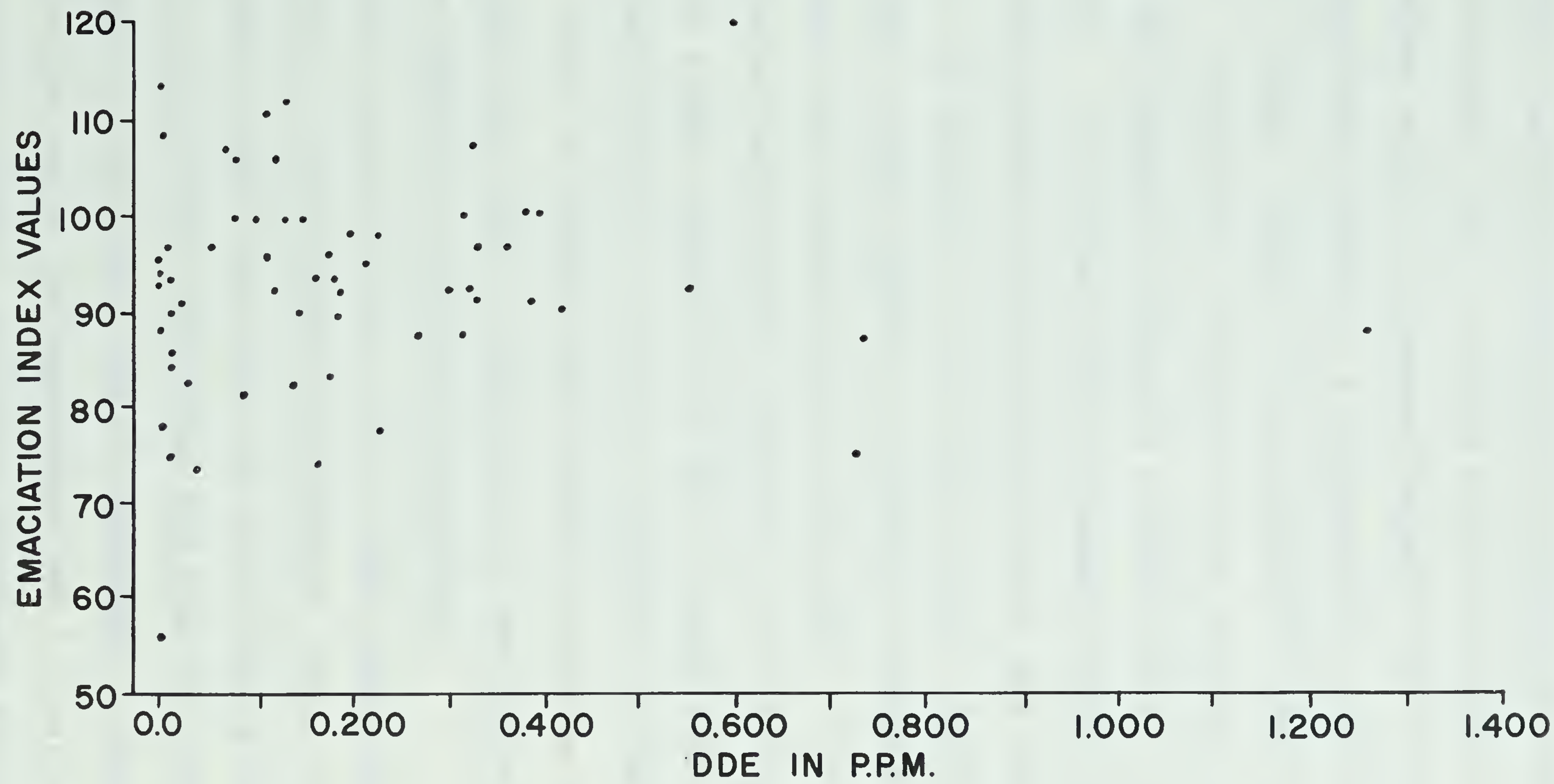

a.
c.
b.
EMACIATION INDEX VALUES
120
110
100
90
80
70
60
50
0.0
0.200
0.400
0.600
0.800
1.000
DIELDRIN IN P.P.M.
DDD IN P.P.M.
DDT IN P.P.M.

Fig. 27. Scatter plot of DDE residues in brain tissue versus emaciation indices of California quail.



EMACIATION INDEX VALUES
120
110
100
90
80
70
60
50
0.0
0.200
0.400
0.600
0.800
1.000
1.200
1.400
DDE IN P.P.M.

the following tissues: brain, heart, kidney, liver, and breast or leg muscle) were than analyzed for pesticide residues (McEwan and Brown, 1966). A bird with 0.4 p.p.m. of dieldrin in its tissues showed no abnormal behavior until collected, 9 days after being treated. A bird with 0.6 p.p.m appeared normal for 9 days, though it was less active when collected on day 10. A bird with 1.0 p.p.m. acted normally for 6 days; this bird was severely injured by a hawk on day 7 (McEwan and Brown, 1966). In another study a pheasant, which showed symptoms of pesticide poisoning when captured alive, was found to contain 0.10 p.p.m. of dieldrin in its breast muscle (Labisky and Lutz, 1967). Brain tissue appears to accumulate dieldrin to a slightly lesser extent than breast muscle (Table XIX). The California quail collected had dieldrin residues up to 0.310 p.p.m. in their brain tissue (seven out of the 16 birds with dieldrin residues had more than 0.05 p.p.m. dieldrin in their brain tissue). Thus, it appears that dieldrin could be toxic to certain individual quail, though none of the birds collected showed any symptoms of pesticide poisoning.

DDT and its metabolites (DDD and DDE) are less toxic than dieldrin to warm-blooded vertebrates (Rudd, 1964). One woodcock fed 10 doses (one per day) of 100 mg/kg body weight of 50 per cent wettable DDT powder and then fed reduced rations for a further 10 days survived the treatment. This bird, when analyzed at the end of the experiment had 2.7 p.p.m. of DDT residues in its tissues. Two other woodcocks had 47.1 p.p.m. (dosage 200 mg/kg) and 7.9 p.p.m. (dosage 500 mg/kg) DDT in their tissues. Both of these birds died during the 10 day

semi-starvation period (Stickel, Dodge, Sheldon, Dewitt, and Stickel, 1965). The levels of DDT residues found in California quail reached 0.814 p.p.m., DDD residues reached 0.342 p.p.m., and DDE residues reached 1.26 p.p.m. The last two are less toxic than DDT to birds (Rudd, 1964). These residue levels are well below the 2.7 p.p.m. found in the woodcock that survived the 10 day period of semi-starvation.

Lindane and endrin were found in only one bird each. Neither are commonly used on the orchards in the Okanagan Valley.

No methoxychlor residues were found in any of the birds analyzed. However, methoxychlor is not readily stored in fatty tissue (Martin, 1961), thus the absence of residues does not mean that these birds had not been in contact with this pesticide. However, it is even less toxic than DDT to warm-blooded animals (Rudd, 1964), and, if used in orchards at the usually recommended rates, probably would not cause any harmful effects to California quail or other bird species (Reid, 1951).

Synergestic effects of pesticides on California quail

The synergestic action of chlorinated hydrocarbon pesticides with organophosphate pesticides can be extremely dangerous (Frawley, 1965). However, as no analyses for the presence of organophosphates in the blood of California quail could be made during the study, the effects of organophosphates or of synergism between these two classes of pesticides on these birds is not known.

Scatter plots of pesticide residues versus emaciation indices of the birds analyzed were made to test the possibility of synergism of various combinations of heptachlor (and/or its

epoxide), DDT (and/or its metabolites), and dieldrin (Figs. 28 and 29). All residue values were recorded as equivalents of DDT in parts per million. None of the regression co-efficients were significant; no synergistic effects were evident.

Effects of pesticides on quail populations.

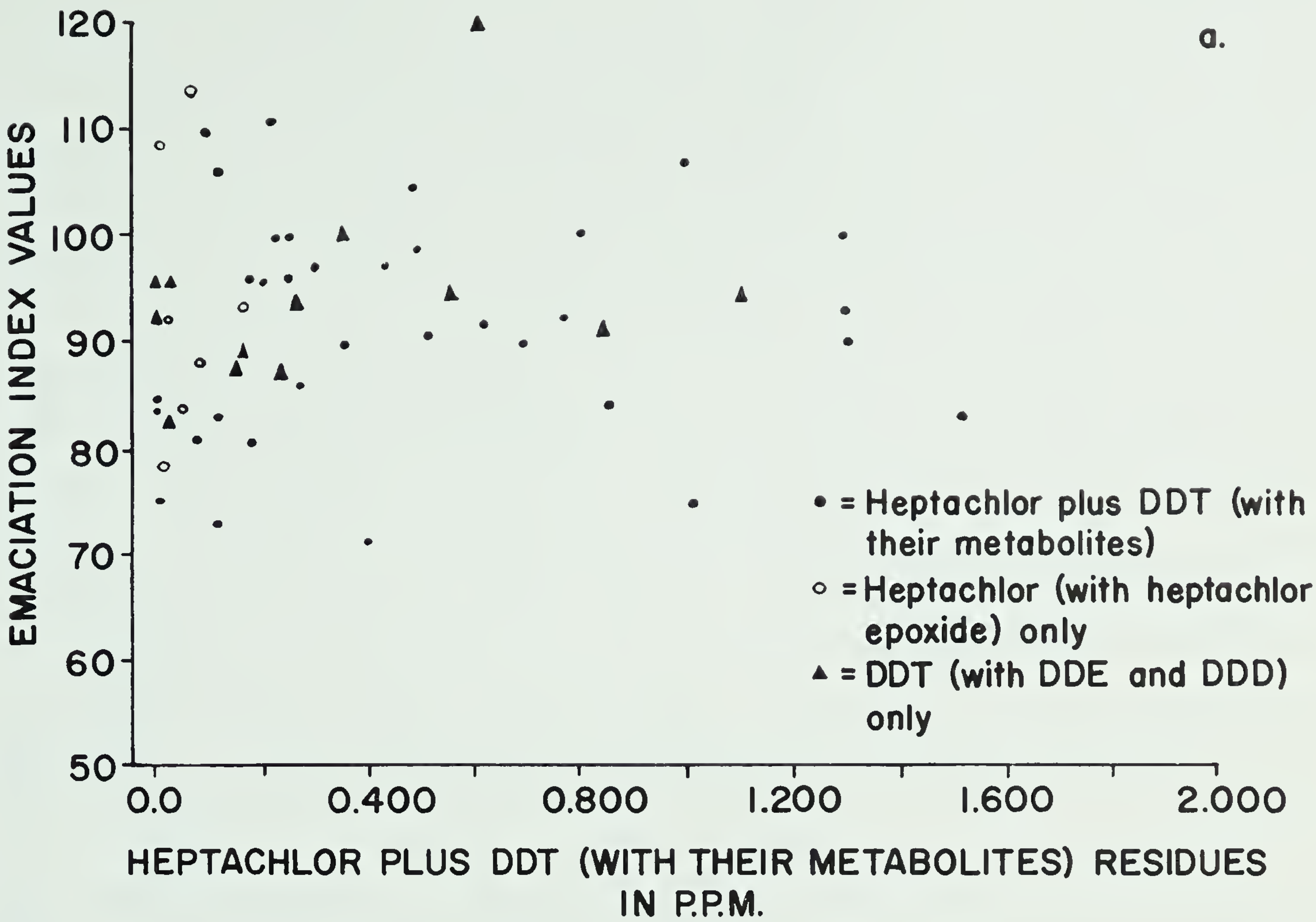
According to Emlen and Glading (1945) fair to good quail habitat (such as study areas 1 and 2) should, in the pre-breeding season, have one California quail per 5 to 15 acres; poor to marginal quail habitats (such as areas 3 and 4) should have one quail per 15 to 100 acres. The actual pre-nesting population (from personal observations) and the number of acres per bird for each area in 1965 are given in Table XXIV. It is evident from the table that the actual quail population for each of the areas is what would be expected from the evaluation of the type of quail habitat present. It appears that the pesticide levels ingested by California quail are insufficient to cause any marked reduction in the populations inhabiting the orchard areas of the Okanagan Valley.

One way that pesticides could reduce quail populations is by causing sterility. It has been demonstrated in domestic fowl that sublethal doses of pesticides can produce sterility in the birds so treated (Rubin, Bird, Green, and Carter, 1947). In this connection a total of five samples of ovaries and one egg from quail collected from area 2 were analyzed for pesticide residues. It is interesting to note that from one bird the ovary, with preovulatory follicles, had a total residue value of 1.3 p.p.m. while an oviducal egg from the same bird had a total residue value of 3.8 p.p.m.

Fig. 28. Scatter plots of pesticide residues in brain tissue versus emaciation indices of California quail.

(a) Heptachlor and DDT (with their metabolites) residues.

(b) Heptachlor (with its epoxide) and dieldrin residues.


a.
EMACIATION INDEX VALUES
120
110
100
90
80
70
60
50
0.0
0.400
0.800
1.200
1.600
2.000
• = Heptachlor plus DDT (with their metabolites)
○ = Heptachlor (with heptachlor epoxide) only
▲ = DDT (with DDE and DDD) only
HEPTACHLOR PLUS DDT (WITH THEIR METABOLITES) RESIDUES IN P.P.M.

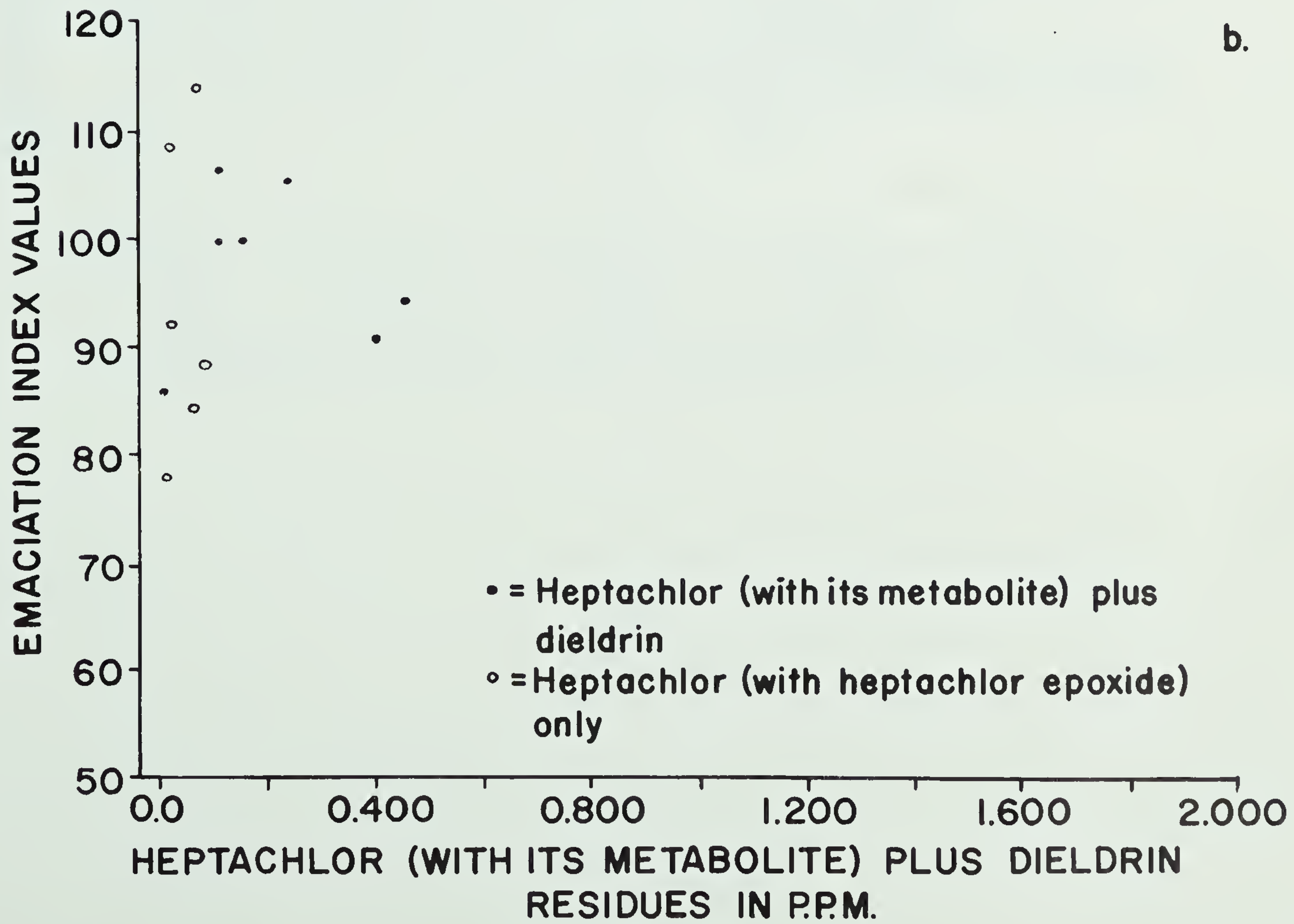

b.
EMACIATION INDEX VALUES
120
110
100
90
80
70
60
50
0.0
0.400
0.800
1.200
1.600
2.000
• = Heptachlor (with its metabolite) plus dieldrin
○ = Heptachlor (with heptachlor epoxide) only
HEPTACHLOR (WITH ITS METABOLITE) PLUS DIELDRIN RESIDUES IN P.P.M.

Fig. 29. Scatter plot of dieldrin and DDT (with its metabolites) residues in brain tissue versus emaciation indices of California quail.

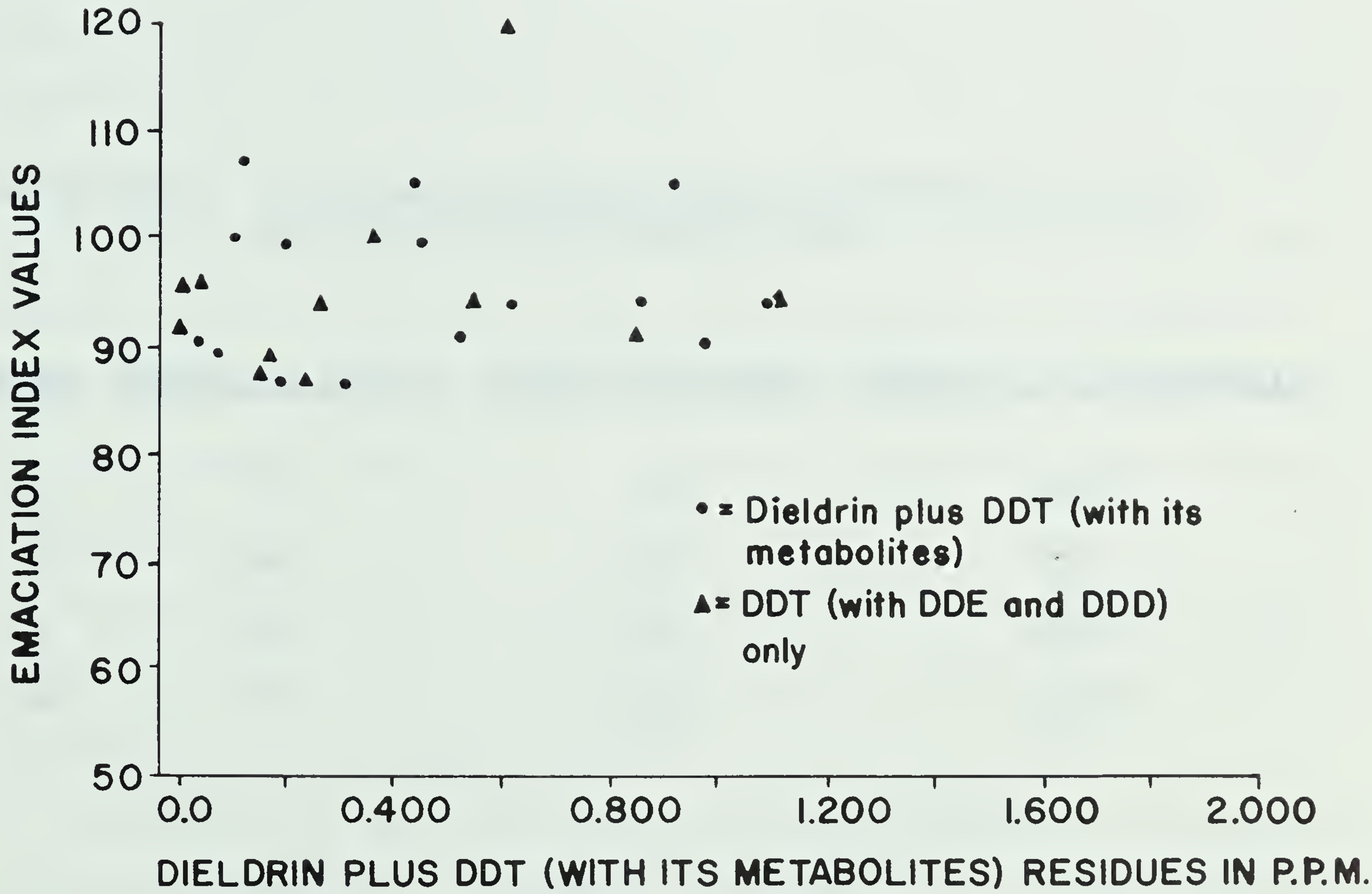

EMACIATION INDEX VALUES
120
110
100
90
80
70
60
50
0.0
0.400
0.800
1.200
1.600
2.000
DIELDRIN PLUS DDT (WITH ITS METABOLITES) RESIDUES IN P.P.M.
• = Dieldrin plus DDT (with its metabolites)
▲ = DDT (with DDE and DDD) only

Table XXIV. Pre-nesting populations of California quail for each study area in 1965.

Area	Number of birds	Number of acres	Density in birds/acre
1	6	30	1/45
2	20	150	1/8
3	14	640	1/40
4	3	125	1/40

Genelly and Rudd (1956) found that in pheasants a DDT level of 150 p.p.m. in the egg was needed before any significant decrease in viability of the young (to 6 weeks of age) was noticed. More recently Cooch (1964) reported that mallards (*Anus platyrhynchos*) laying eggs containing only 2 p.p.m. DDT had significantly lower hatching success. However, there probably are differences among bird species with regard to the effect of DDT on hatchability, just as there are decided differences in the susceptibility to pesticides among different species of birds (Reid, 1951). As California quail are closely related to pheasants and occupy similar types of habitat, the level of DDT necessary to lower the reproductive success of quail may be closer to that of pheasants than to that of mallards. The highest DDT residue level found in California quail ovaries and eggs was 1.2 p.p.m.

The highest levels of DDD and DDE, both of which are less toxic than DDT, found in California quail ovaries and eggs was 0.1 and 3.0 p.p.m. respectively.

Dieldrin is much more toxic to warm-blooded vertebrates than DDT (Rudd, 1964). Dieldrin at levels as low as 3 p.p.m. in the eggs resulted in lowered reproductive success in pheasants (Genelly and Rudd, 1956). The highest dieldrin residue level found in California quail ovaries and eggs was 1.3 p.p.m.

No heptachlor, or its epoxide, was found in any of the eggs and ovaries analyzed although one female quail from which these samples were taken had 0.005 p.p.m. of heptachlor in its brain tissue.

It appears that the pesticide levels present in the ovaries

and eggs of California quail are not high enough to cause any significant decreases in the reproductive success of this species in the Okanagan Valley.

The number of 4 to 7 week old young per brood (obtained by personal observations) for each area for each year is given in Table XXV. From the data presented there is no difference between these areas in the productivity of the California quail inhabiting them. The average brood sizes of 9-10 obtained here compare well with the average brood size of 8.4 reported for six week old California quail by Edminster (1954). Another measure of productivity is the early fall juvenile: adult ratio; a ratio of two or more juveniles to each adult is considered to indicate good to excellent productivity (Edminster, 1954). From the number of adults and juveniles trapped in August and September of 1965, area 1 had a ratio of 4:1, area 3 had a ratio of 2:1. Thus it appears that both of these sprayed areas have from good to excellent productivity of California quail (assuming that the population structure does not change in the early fall; no obvious change was noticed up to mid-September of either year). Both of these measures indicate that there is no marked reduction of productivity in the sprayed areas.

In summary, it appears that none of the pesticides analyzed for, with the possible exception of dieldrin, at the levels present in the brain tissue of California quail, cause the individual birds any harm. It also appears that none of these pesticides cause a marked reduction in the population of California quail in the Okanagan Valley.

Table XXV. Productivity of California quail from each study area for each year. Number of young is the number of fledged young (4-7 wks. old) seen.

Area	Year	No. of potential broods*	No. broods	Total no. young	Average no. young/brood
1	1965	4	4	40	10
	1966	2	2	20	10
2	1965	4**	3	?***	?***
	1966	-	-	-	-
3	1965	4	4	38	9.5
	1966	3**	2	18	9
4	1965	2	2	18	9
	1966	-	-	-	-

* The number of potential broods is the number of pairs observed during the nesting season. These do not include unpaired birds or birds killed before they were able to bring off a brood. No immigration of pairs into any of the study areas was noticed during the study, although an immigration of individual birds was noticed.

** In each case one pair was observed that never had any young with them throughout the summer.

*** 1 brood from area 2 in 1965 had 8 young.

Effect of Pesticides on the Parasites of California Quail

Flickinger and Keith (1965) found that 50 p.p.m. of DDT in the diet of white pelicans (*Pelecanus erythrorhynchos*) caused the elimination of both endo- and ectoparasites from these birds. Lower dosages of DDT were not fed these birds, however, so the minimum dosage required for elimination of parasites is not known. To test the possibility that pesticides ingested by California quail had an effect on the total number of helminths present, scatter plots were made of the amount of pesticide residues in the brain tissue of the California quail against the total number of helminths in the intestinal tract of the bird (Figs. 30-32). The total pesticide residues (Fig. 30a) are recorded as equivalents of DDT in parts per million. In no case was a significant regression co-efficient obtained. Thus it appears that the pesticide levels ingested by California quail have no effect on the number of intestinal helminths present.

The effect of pesticides on the ectoparasites of California quail has been discussed earlier under *Colinicola docophoroides*.

Fig. 30. Scatter plots of pesticide residues in brain tissue versus total helminth numbers.

(a) Total pesticide residues. Values are reported as equivalents of DDT in p.p.m.

(b) Heptachlor residues.

(c) Heptachlor epoxide residues.

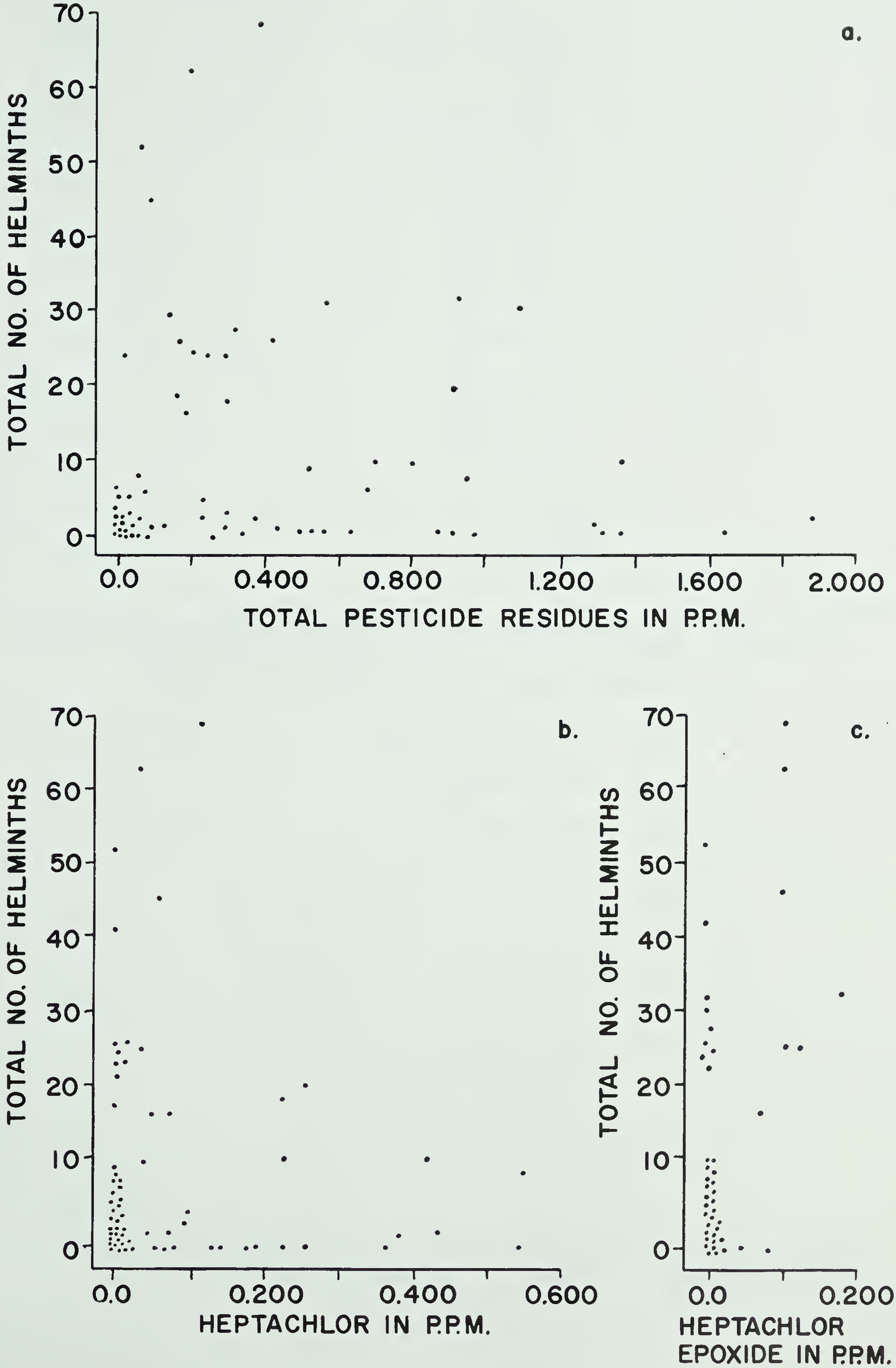

a.
TOTAL NO. OF HELMINTHS
0
10
20
30
40
50
60
70
0.0
0.400
0.800
1.200
1.600
2.000
TOTAL PESTICIDE RESIDUES IN P.P.M.
b.
TOTAL NO. OF HELMINTHS
0.0
0.200
0.400
0.600
HEPTACHLOR IN P.P.M.
c.
TOTAL NO. OF HELMINTHS
0.0
0.200
HEPTACHLOR
EPOXIDE IN P.P.M.

Fig. 31. Scatter plots of pesticide residues in brain tissue versus total helminth numbers.

(a) Dieldrin residues.

(b) DDT residues.

(c) DDD residues.

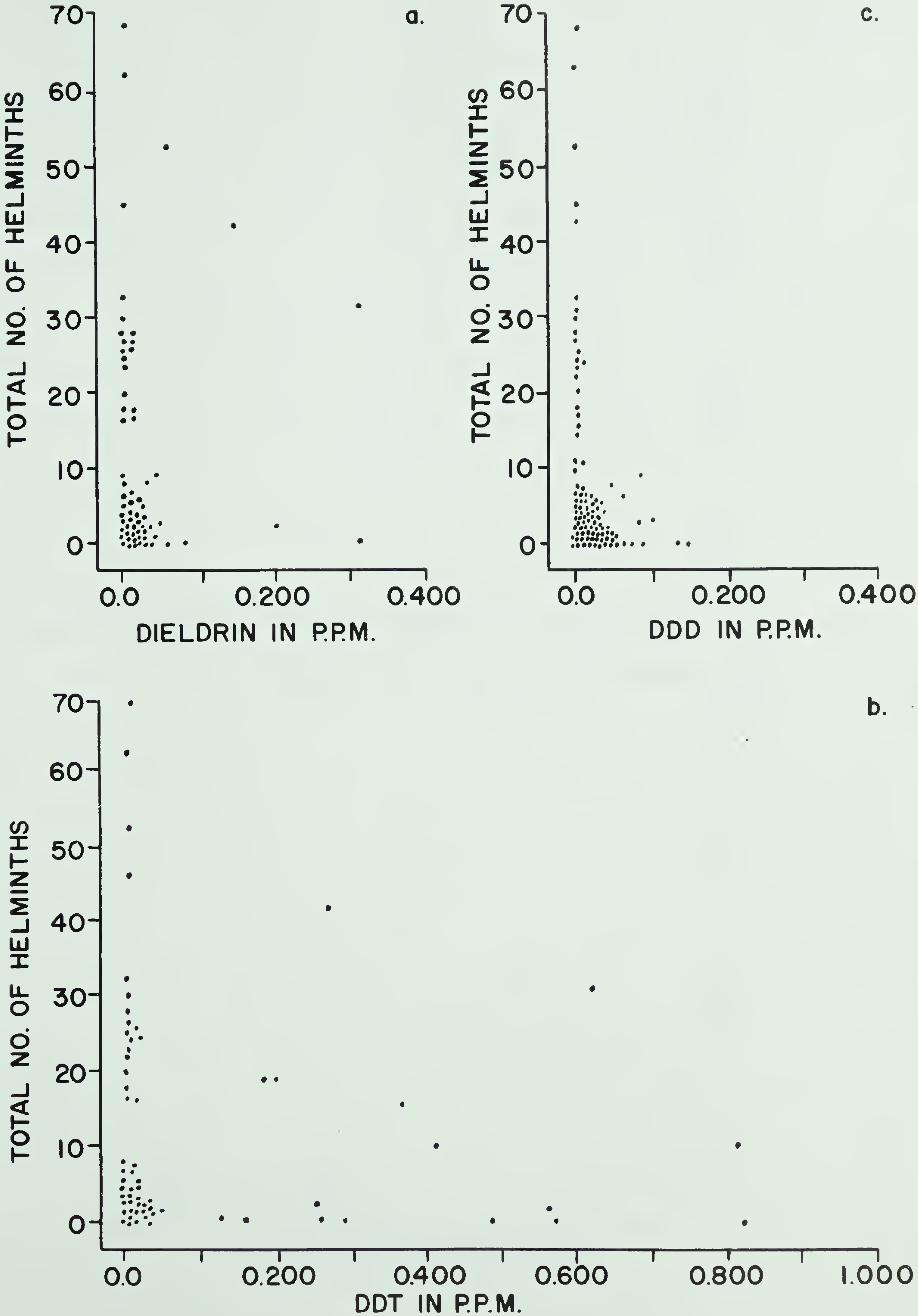
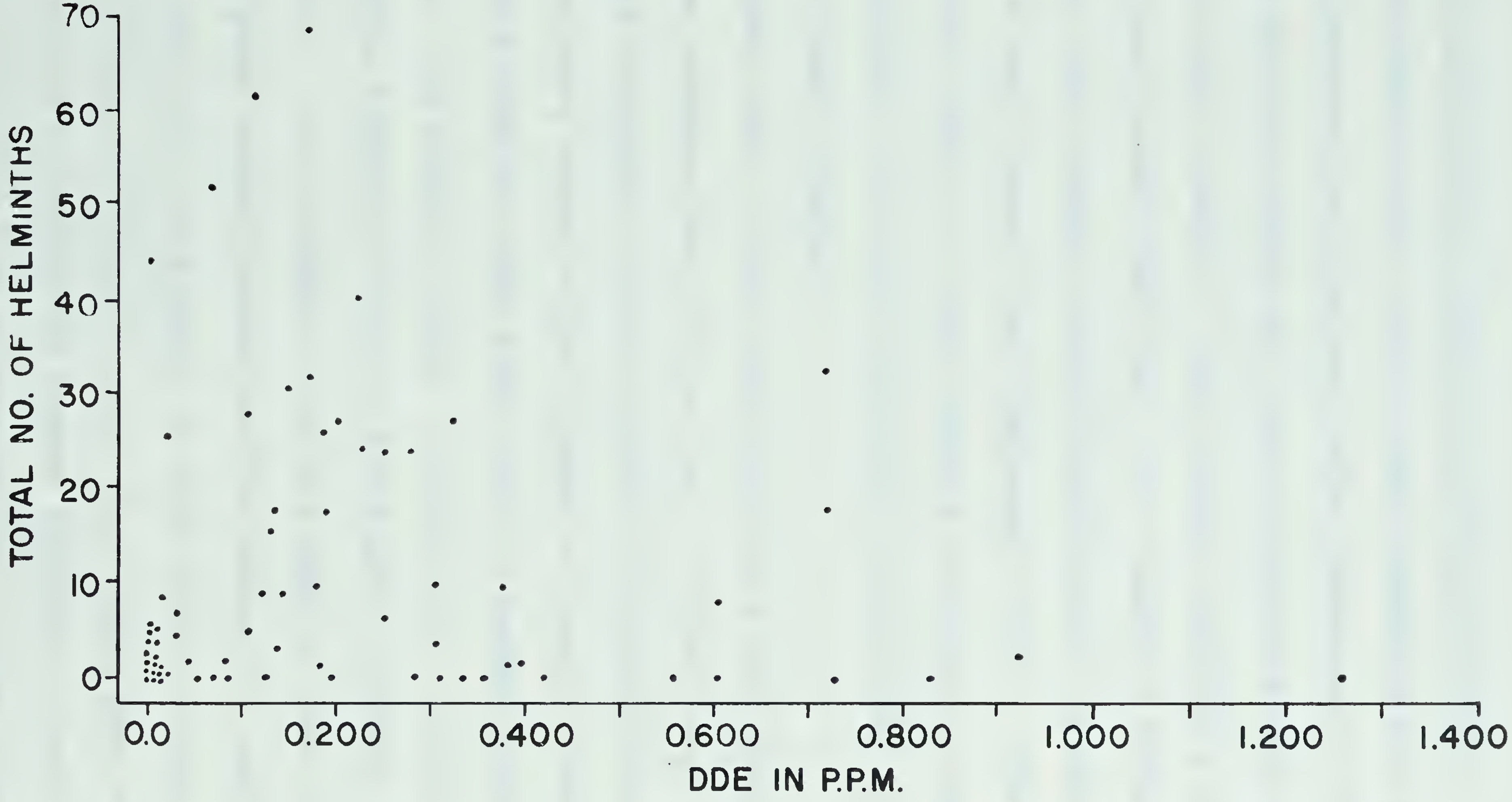
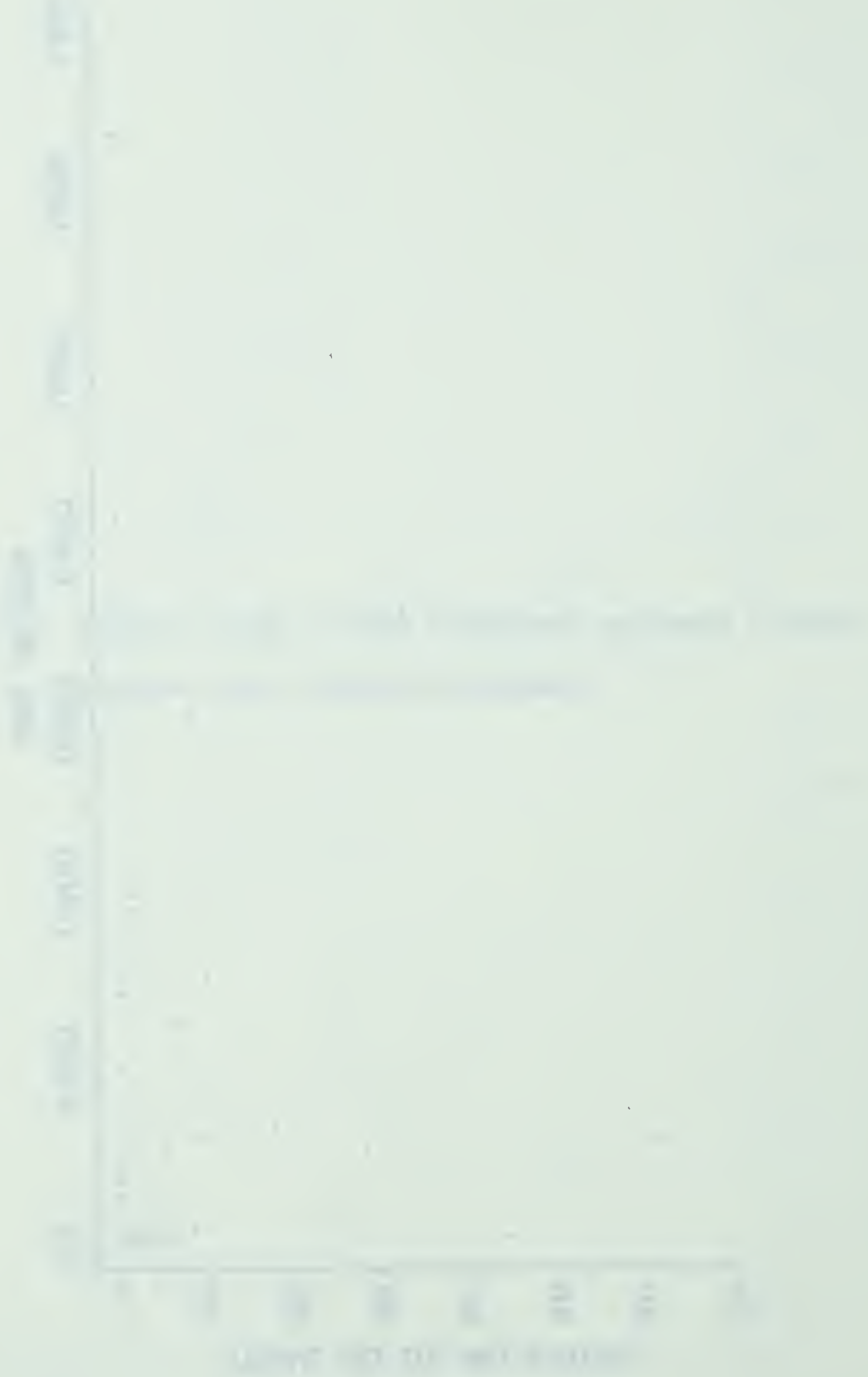

a.
TOTAL NO. OF HELMINTHS
0
10
20
30
40
50
60
70
0.0
0.200
0.400
DIELDRIN IN P.P.M.
c.
TOTAL NO. OF HELMINTHS
0
10
20
30
40
50
60
70
0.0
0.200
0.400
DDD IN P.P.M.
b.
TOTAL NO. OF HELMINTHS
0
10
20
30
40
50
60
70
0.0
0.200
0.400
0.600
0.800
1.000
DDT IN P.P.M.

Fig. 32. Scatter plot of DDE residues in brain tissue versus total helminth numbers.



TOTAL NO. OF HELMINTHS
70
60
50
40
30
20
10
0
0.0
0.200
0.400
0.600
0.800
1.000
1.200
1.400
DDE IN P.P.M.



DISCUSSION

Reasons for Low Residue Levels in California Quail

As California quail are the most vegetarian of all of the North American gallinaceous birds (Edminster, 1954), diet is likely the main reason why these birds have such low residue amounts in their tissues. Even juvenal California quail, which eat more animal food when 3 to 4 weeks old than at any other time, only consume enough animal matter to make up 33 per cent of their total diet (Edminster, 1954). Thus these birds are not taking in large amounts of types of food, such as invertebrates, that can concentrate pesticides in large amounts in their tissues.

American coots (*Fulica americana*) are also mainly vegetarian; plant items average about 90 per cent of their diet (Jones, 1940). In a sample of aquatic birds analyzed for pesticide residues, only traces were found in the tissues of coots, whereas fish-eating birds from the same area, such as common egrets (*Casmerodius albus*) and western grebes (*Aechmophorus occidentalis*) had total residue levels as high as 689 p.p.m. in their tissues (Rudd, 1965). It is evident that the type of food eaten by a bird to a great extent determines the amount of pesticide residues which will be present in that bird's tissues.

In addition, California quail do a large part of their feeding outside the orchards proper (personal observations), where there would be less contamination of food plants.

Spray residues on cover plants in orchards are usually washed off by irrigation water or rainfall (Bowman, 1950). It

has been noted that pheasant mortality in the Okanagan Valley occurs only during certain conditions: birds of the most susceptable age (3 to 4 weeks old, when a large part of their diet (about 75 per cent) is made up of animal food (Allen, 1956)), palatable cover in orchards, and no rainfall or irrigation so that the spray deposit would remain on the cover plants for a considerable period of time (Rye, in Bowman, 1950). On foliage the half-life of DDT is from 11 to 15 weeks; the half-life of dieldrin is about 6 weeks (Rudd, 1965).

In 1966 the two orchard study areas were irrigated at least once a week. In 1965 study area 2 was not irrigated but it was apparently not sprayed either. In the Okanagan Valley rainfall, of sufficient intensity to wash pesticide residues off the cover crop foliage, usually occurs at least once every two weeks.

When people are working in the orchards, such as during spraying operations, California quail usually leave the area. Thus, they are not likely to come into direct contact with the spray.

Thus, it appears that the feeding and behavioural habits of California quail prevent them from coming into contact with and ingesting large amounts of pesticides.

Probable Evolutionary Effects

It is a well established fact that invertebrates can, in a relatively short period of time, acquire resistance to the majority of pesticides (Rudd, 1965). In such cases a portion of the population has always been resistant to certain poisons (such as DDT) and, with the elmination of other segments of

the population through the use of pesticides, these resistant strains have increased greatly. A similar phenomenon has been recorded for bacteria developing resistance to certain kinds of antibiotics. Thus, it is entirely possible that vertebrates, given enough time and a sufficient population turnover, could also develop resistance to some of the pesticides. Birds, such as California quail, which have been exposed more or less continuously to such pesticides for a long period of time, could show such a tendency.

Presence of Heptachlor

The presence of heptachlor and heptachlor epoxide residues in California quail is somewhat mystifying. In answer to a letter to the Summerland branch of the Canadian Department of Agriculture, Mr. K. Williams, chemist at the Entomology Laboratory replied, in part, "Heptachlor has been used to a very limited extent for the control of soil insects in vegetable plantings and it has never been used in orchards. The last recommended use for heptachlor was in the 1960 vegetable calendar as an alternate to aldrin and dieldrin, but was not widely used because of price. The recommended rate was 4 lb actual per acre and any applied would be in the area from Kelowna north to Kamloops and Salmon Arm.

"I am rather surprised that there is a significant amount of heptachlor (or its epoxide) in quail."

Kelowna, the place furthest south where heptachlor was used, is approximately 24 air miles from area 1, the furthest north of all of the collecting areas. That heptachlor (or its epoxide) is a wide-spread contaminant in the environment

of the entire Okanagan Valley is evident as two of the quail collected from area 4, the non-sprayed area, had heptachlor or heptachlor epoxide residues in their brain tissue. There was no trace of any of the other pesticides in any of the birds collected from this area. As California quail are quite sedentary in habits, the heptachlor, or its epoxide, must have been picked up by these birds in this general area.

How heptachlor or its epoxide was spread to these four study areas is not known. There is a possibility of contaminated water being used for orchards irrigated by water pumped from either Skaha Lake (area 2) or the Okanagan River (area 3). Both of these water supplies could become contaminated from runoff water from heptachlor treated fields entering Okanagan Lake in the Kelowna area. Area 1, however, is irrigated by water from a mountain reservoir and none of this water drains or is near any of the areas reported to have been treated with heptachlor in the late 1950's and 1960. Area 4 is 48 air miles from Kelowna, is about 1,000 feet above the valley floor, and does not contain any water supply which drains or comes from areas near any orchard or vegetable raising areas.

It is known that chlordane, a relatively non-persistent chlorinated hydrocarbon, contains heptachlor as a contaminant (March, 1952). However, very little chlordane has been used in the Okanagan Valley and no spraying was done within 4 miles of study area 4. No mass movements of insects were noticed moving into any of the study areas, so the possibility of insects bringing heptachlor into these areas is also discounted.

Use of California Quail as an Indicator of Pesticides Present in the Environment

The possibility of using game birds as indicators of the type and amount of pesticide residues present in the environment is an interesting facet of future ecological studies. In the Okanagan Valley, a bird such as the California quail would be a good choice for such an indicator, as these birds are sedentary residents, the home range being about 50 acres in extent (Edminster, 1954). Thus, the pesticide residues found in the tissues of California quail would be derived from the immediate area. By using indicator species such as this, the presence of hitherto unsuspected environmental contaminants (such as heptachlor in the present study) may be discovered. Because of the low residue levels present in California quail, at least 10 birds from each area should be analyzed for meaningful results. The possibility of California quail being resistant to pesticides would not affect their use as an indicator as they would still be accumulating the residues in their tissues.

Need for Further Studies

To better evaluate the results of field studies such as this one, more data is needed from laboratory tests. Experiments should be carried out to determine the LD_{50} for California quail for each of the pesticides to be analyzed for in further field studies. Then the residue levels found in the birds taken from wild populations could be expressed as fractions of the LD_{50} value for each pesticide. These fractions, when totalled, would give an indication of the total number of LD_{50}'s present in the bird's tissues, and thus give a good

indication of the effect (sublethal, lethal, or over the lethal level) of such a pesticide load on the bird. Such laboratory tests should, if possible, include every pesticide normally used in the proposed field study area.

CONCLUSIONS

From the data and evidence presented here the following general conclusions can be made:

1. *Rhabdometra tomica* is a synonym of *Rhabdometra odiosa*.

2. There is no evidence of the parasites of California quail from the Okanagan Valley having any significant effect on their hosts in the summertime.

3. The pesticides analyzed (heptachlor, heptachlor epoxide, dieldrin, DDT, DDD, DDE, lindane and endrin) appear to have no significant effect on California quail in the Okanagan Valley. However, a few birds had levels of dieldrin as high as or higher than that reported by Labisky and Lutz (1967) in a pheasant that showed pesticide poisoning symptoms. Analyses were made for only two of the 14 most commonly used pesticides in the Okanagan Valley.

4. California quail would be good "indicators" of the presence of certain pesticides in the environment.

REFERENCES CITED

Allen, D. L. 1956. Pheasants in North America. Wildlife Management Institute, Washington, D. C. 490 p.

American Ornithologists Union. 1957. Check-list of North American birds (5th. ed.). 691 p.

Babero, B. B. 1953. Studies on the helminth fauna of Alaska. XVI. A survey of the helminth parasites of ptarmigan (*Lagopus* spp.). Jour. Parasit., 39:538-546.

Bannerman, D. A. 1955. The birds of the British Isles. Vol. IV. Oliver and Boyd, Edinburgh. 259 p.

Barnett, D. C. 1950. The effects of some insecticide sprays on wildlife. Proc. 30th Annual Conf. West. Assoc. State Game and Fish Commissioners, 30:125-134.

Bendell, J. F. 1955. Disease as a control of a population of blue grouse, *Dendragapus obscurus fuliginosus* (Ridgway). Can. J. Zool., 33(3):195-223.

Bent, A. C. 1932. Life histories of North American gallinaceous birds. Bull. 162, Smithsonian Institution, Washington, D. C. 490 p.

Bequaert, J. C. 1954. Hippoboscidae or louse-flies (Diptera) of mammals and birds. Part II. Taxonomy, evolution and revision of American genera and species. Ent. Americana, 34 (new series):1-232.

_______________ 1957. Hippoboscidae or louse-flies (Diptera) of mammals and birds. Part II. Taxonomy, evolution and revision of American genera and species. Ent. Americana, 36(new series):417-611.

Bishopp, R. L. and Helen L. Trembley. 1945. Distribution and hosts of certain North American ticks. Jour. Parasit., 31(1):1-54.

Bowman, R. L. 1950. A study of bird and mammal population in orchards of the Okanagan Valley, British Columbia, with special reference to the effects of orchard sprays upon them. Canadian Wildlife Service, Ottawa. M. S. 85 p.

Boykins, E. A. 1967. The effects of DDT contaminated earthworms in the diet of birds. Bioscience, 17(1):37-39.

British Columbia Department of Agriculture. 1966. 1966 Tree-fruit spray calendar. Interior districts. Queen's Printer, Victoria. 44 p.

Canada Department of Agriculture. 1966. Compendium on registered uses of pesticides in Canada. Queen's Printer, Ottawa. Mimeo, unpaged.

Carl, G. C. and C. J. Guiguet. 1958. Alien animals in British Columbia. Queen's Printer, Victoria. 94 p.

Clay, Theresa. 1938. A revision of the genera and species of Mallophaga occurring on gallinaceous hosts. Part I. *Lipeurus* and related genera. Proc. zool. Soc. Lond., Ser. B, 108:109-204.

_______________ 1940. Genera and species of Mallophaga occurring on gallinaceous hosts. Part II. *Goniodes*. Proc. zool. Soc. Lond., Ser. B, 110:1-120.

Cooch, F. C. 1964. Address at the 28th Federal-Provincial Wildlife Conference, 1964, Charlottetown, Prince Edward Island, as quoted in Myers, M. T. 1964. The widespread pollution of soil, water, and living things by toxic chemicals used in insect control programmes. University of Alberta, Calgary, Mimeo. 54 p.

Cornwell, G. W. and A. B. Cowan. 1963. Helminth populations of the canvasback (*Aythya valisineria*) and host-parasite-environmental interrelationships. 28th North American Wildlife and Natural Resources Conference Transactions. 173-199.

Cowan, I. M. and C. J. Guiguet. 1965. The mammals of British Columbia. 3rd. ed. Queen's Printer, Victoria. 414 p.

Cram, Eloise B. 1927. Bird parasites of the nematode suborders Strongylata, Ascaridata and Spirurata. Bull. 140. U. S. Nat. Mus. Washington. 482 p.

_______________ 1931. In Stoddard, H. L. 1931. The bob-white quail. Charles Scribner's Sons. New York. 490 p.

_______________ 1934. *Habronema incerta* (Smith, Fox, and White, 1908) Gendre 1922. In a new bird host in a new locality. Jour. Parasit., 20(3):74-75.

Dahlen, J. H. and A. O. Haugen. 1954. Acute toxicity of certain insecticides to the bobwhite quail and mourning dove. J. Wildl. Mgmt., 18(4):477-481.

Dogiel, V. A. 1964. General parasitology. Oliver and Boyd. Edinburgh. 515 p.

Edminster, F. C. 1954. American game birds. Charles Scribner's Sons. New York. 490 p.

Emlen, J. T. Jr. and B. Glading. 1945. Increasing valley quail in California. Bull. 695, Univ. Calif. Agr. Exp. Sta. 56 p.

Emerson, K. C. 1951. List of Mallophaga from gallinaceous birds of North America. J. Wildl. Mgmt., 15:193-195.

______________. 1964. Checklist of the Mallophaga of North America (north of Mexico). Part I. Suborder Ischnocera. Dugway Proving Ground, Dugway, Utah. 171 p.

Fernald, H. T. and H. H. Shepard. 1955. Applied entomology. McGraw-Hill, New York. 385 p.

Fisher, D. V. 1964. Tree fruit growing in the interior of British Columbia. Queen's Printer, Ottawa. 58 p.

Flickinger, E. L. and J. O. Keith. 1965. Effects of DDT and toxaphene in diets of young white pelicans. *In* Effects of pesticides on fish and wildlife. Fish and Wildlife Circ. 226, Washington, D. C. 34-35.

Frawley, J. P. 1965. Synergism and antagonism. *In* Research in pesticides. C. O. Chichester ed. Academic Press. N. Y. 380 p.

Genelly, R. E. and R. L. Rudd. 1956. Effects of DDT, toxaphene, and dieldrin on pheasant reproduction. Auk, 73(4):529-539.

Glading, B. H., H. H. Biswell, and C. F. Smith. 1940. Studies on the food of the California quail in 1937. J. Wildl. Mgmt., 4(2):128-144.

Grinnell, J., H. C. Bryant, and T. L. Storer. 1918. The game birds of California. University of California Press, Berkeley. 642 p.

Guiguet, C. J. 1961. The birds of British Columbia. (4) Upland game birds. Queen's Printer, Victoria. 47 p.

Gullion, G. W. 1957. Gambel quail disease and parasite investigations in Nevada. Amm. Mid. Nat., 57(2):414-420.

Hearle, E. 1938. The ticks of British Columbia. Sc. Agric., 18(7):341-354.

Herman, C. M. 1945. Gapeworms in California quail and chuckar partridge. Calif. Fish and Game, 30:112-118.

_____________ and J. E. Chattin. 1943. Epidemiological studies on coccidiosis of California quail. I. Occurrence of *Eimeria* in wild quail. Calif. Fish and Game, 29(4): 168-179.

Jewett, S. A., W. P. Taylor, W. T. Shaw, and J. W. Aldrich. 1953. Birds of Washington State. University of Washington Press, Seattle. 800 p.

Johnson, A. W. 1965. The birds of Chile and adjacent regions of Argentina, Bolivia and Peru. Vol. I. Platt Establecimientos Graficos S. A., Buenos Aires. 398 p.

Jones, J. C. 1940. Food habits of the American coot with notes on distribution. U. S. Dept. Int., Wildlife Research Bull. 2. Washington, D. C. 52 p.

Jones, Myrna F. 1929. Tapeworms of the genera *Rhabdometra* and *Paruterina* found in the quail and yellow-billed cuckoo. Proc. U. S. Nat. Mus., 75(20):1-18.

Kasimov, G. S. 1956. Gel'mintofauna okhatniche'-promyslovykh ptits. Moscow. 554 p.

Krogsdale, J. T. 1950. Survey of endoparasites in California valley quail of the Palouse Area. Trans. Amer. Microsc. Soc., 69(4):398-402.

Labisky, R. F. and R. W. Lutz. 1967. Responses of wild pheasants to solid-block applications of aldrin. J. Wildl. Mgmt., 31(1):13-24.

Leopold, A. 1933. Game management. Charles Scribner's Sons. New York. 481 p.

Leopold, A. S. 1959. Wildlife in Mexico: the game birds and mammals. University of California Press, Berkeley. 584 p.

Lewin, V. 1963. Reproduction and development of young in a population of California quail. The Condor, 65(4): 249-278.

__________ 1965. The introduction and present status of California quail in the Okanagan Valley of British Columbia. The Condor, 67(1):61-66.

Malcomson, R. O. 1960. Mallophaga from birds of North America. The Wilson Bulletin, 72(2):182-197.

March, R. B. 1952. The resolution and chemical and biological characterization of some constituents of technical chlordane. J. Econ. Ent., 45(3):452-456.

Martin, H. 1961. Guide to chemicals used in crop production. (4th ed.). Canada Dept. Agriculture, Research Branch, Pub. 1093. Queen's Printer, Ottawa. 387 p.

Matevosian, E. M. 1963. Dilepidoidea - lentochnye gel'minty domashnikhi dikikh zhivotnykh. Moscow. 682 p.

McEwan, L. C. and R. L. Brown. 1966. Acute toxicity of dieldrin and malathion to wild sharp-tailed grouse. J. Wildl. Mgmt., 39(3):604-611.

Munro, J. A. and I. M. Cowan. 1947. A review of the bird fauna of British Columbia. British Columbia Provincial Museum Publ. No. 2. 285 p.

Nuttal, G. H. and C. Warburton. 1915. Ticks. A monograph of the Ixodoidea. Part III. The genus *Haemaphysalis*. Cambridge University Press, Cambridge. 349-550.

Ontario Research Foundation. 1965. Report ORF 65-4. Unpaged.

O'Roke, E. C. 1928. Parasites and parasitic disease in the California valley quail. Calif. Fish and Game, 14(3): 193-198.

____________ 1932. Parasitism of the California valley quail by *Haemoproteus lophortyx*, a protozoan blood parasite. Calif. Fish and Game, 18(3):223-238.

Pough, R. H. 1957. Audubon western bird guide. Doubleday and Co., New York. 316 p.

Raitt, R. L. Jr. 1961. Plumage development and molts of California quail. The Condor, 63(4):294-303.

Reid, D. B. 1951. An investigation into the effects of orchard sprays upon wildlife in the Okanagan Valley, British Columbia. Canadian Wildlife Service, Ottawa. M. S. 75 p.

Reid, M. W. 1962. Chicken and turkey tapeworms. Georgia Agr. Exp. Sta., Athens, Georgia. 71 p.

Rubin, M., H. R. Bird, N. Green, and R. H. Carter. 1947. Toxicity of DDT to laying hens. Poultry Science, 26(4):410-413.

Rudd, R. L. 1964. Pesticides and the living landscape. University of Wisconsin Press, Madison. 320 p.

Rye, D. 1950. Pheasant investigations in the Okanagan Valley, B. C. - 1950. *In* Bowman, 1950 (*loc. cit.*).

Schottelius, D. D. 1951. A parasitological study of blue grouse in the Methow Valley of Washington. M. Sc. thesis, State College of Washington. 18 p.

Southwell, T. 1930. The fauna of British India, Cestoda, Vol. II. Taylor and Francis, London. 262 p.

Spector, W. S. 1956. Handbook of biological data. Saunders, Philadelphia. 584 p.

Spencer, G. J. 1957. Further records of Mallophaga from British Columbia Birds. Ent. Soc. of British Columbia, Proc., 53:3-10.

Swales, W. E. 1934. *Rhabdometra odiosa* (Leidy, 1887) Jones, 1929, a cestode parasite of *Pedioecetes phasianellus* in Quebec. Jour. Parasit., 20(5):313-314.

Stickel, W. H., W. E. Dodge, W. G. Sheldon, J. B. Dewitt, and Lucille F. Stickel. 1965. Body condition and responses to pesticides in woodcocks. J. Wildl. Mgmt., 29(1): 147-155.

Stickel, W. H., D. W. Hayne, and Lucille F. Stickel. 1965. Effects of heptachlor contaminated earthworms on woodcocks. J. Wildl. Mgmt., 29(1):132-146.

Taverner, P. A. 1934. Birds of Canada. Bull. 72, Nat. Mus. of Canada. Queen's Printer, Ottawa. 445 p.

Vaurie, C. 1959. Birds of the Palearctic Fauna. Vol. I, Witherby London. 774 p.

__________ 1965. Birds of the Palearctic Fauna. Vol. II. Witherby London. 800 p.

Wehr, E. E. 1933. Occurrence of *Ascaridia lineata* in California valley quail. Jour. Parasit., 31(4):252.

__________ and C. M. Herman. 1956. *Lophortofilaria californiensis* n.g., n.sp. (*Filarioidea, Dipetalonematidae*) from California quail (*Lophortyx californicus*), with notes on its microfilaria. Jour. Parasit., 42(1): 42-44.

Yamaguti, S. 1959. Systema Helminthum. Vol. II. The cestodes of vertebrates. Interscience Pub. Inc., New York. 860 p.

__________ 1961. Systema Helminthum. Vol. III. The nematodes of vertebrates. Interscience Publ. Inc., New York. 1261 p.

APPENDIX I

Other birds caught in quail traps in the Okanagan Valley, British Columbia.

Species	No. caught
Pheasant (*Phasianus colchicus*)*	4
Mourning dove (*Zenaidura macroura*)	13
Red-shafted flicker (*Colaptes cafer*)**	1
Magpie (*Pica pica*)***	1
Robin (*Turdus migratorius*)	4
Starling (*Sturnus vulgaris*)	1
Western meadowlark (*Sturnella neglecta*)	2
Red-winged blackbird (*Agelaius phoeniceus*)	6
Brown-headed cowbird (*Molothrus ater*)	8
Cassin's finch (*Carpodacus cassinii*)****	1
Rufous-sided towhee (*Pipilo erythrophthalmus*)	8
Lark sparrow (*Chondestes grammacus*)****	2
White-crowned sparrow (*Zonotrichia leucophyrs*)****	4
White-throated sparrow (*Zonotrichia albicollis*)****	1

* Pheasants were caught in traps that had too large an entrance

** Red-shafted flicker caught in trap placed near an ant-hill

*** Magpie was in a trap eating a previously caught mourning dove

**** Sparrows and finches were usually able to escape through the one inch wire mesh

APPENDIX II

Collated raw data.

All pesticides are reported in p.p.m.

Total pesticide residue levels are reported as equivalents of DDT in p.p.m.

B = brain tissue

BM = breast muscle tissue

OV = ovarian tissue with preovulatory follicles

E = egg

M = male

F = female

Imm. = immature (yearling) plumage, counted as an adult in text

Ad. = adult plumage

- = tissue not analyzed

X = present, numbers not determined

? = numbers unknown

1965 specimens.

Specimen number	C-1	C-2	C-3	C-4	C-5	C-6
Area collected	2	2	2	2	2	2
Date	5/18	5/20	5/20	5/25	5/25	5/25
Age	Imm.	Imm.	Imm.	Imm.	Imm.	Ad.
Sex	M	F	M	M	M	M
Weight in grams	186.4	202.4	193.0	174.5	185.0	195.9
Rhabdometra	25	50	40	20	10	0
Choanotaenia	0	0	0	0	0	0
Acuaria	0	0	0	0	0	0
Total no. helminths	25	50	40	20	10	0
Goniodes	0	0	0	0	0	0
Colinicola	0	0	0	0	0	0
Ornithomyia	0	0	0	0	0	0
Haemaphysalis	0	0	0	0	0	0
Tissue analyzed	-	-	-	-	-	-
Heptachlor	-	-	-	-	-	-
Heptachlor epoxide	-	-	-	-	-	-
Dieldrin	-	-	-	-	-	-
DDD	-	-	-	-	-	-
DDE	-	-	-	-	-	-
DDT	-	-	-	-	-	-
Lindane	-	-	-	-	-	-
Endrin	-	-	-	-	-	-
Methoxychlor	-	-	-	-	-	-
Total residue	-	-	-	-	-	-
Emaciation index	109	90	109	106	93	113

1965 specimens

Specimen number	C-7	C-8	C-9	C-9a	C-11	C-12
Area collected	1	2	2	2	2	2
Date	5/27	5/27	5/27	5/27	6/7	6/10
Age	Imm.	Imm.	Imm.	-	Imm.	Imm.
Sex	M	F	F	-	F	M
Weight in grams	179.4	196.8	214.9	-	158.6	208.6
Rhabdometra	5	0	25	-	8	30
Choanotaenia	0	0	0	-	0	0
Acuaria	0	0	0	-	0	0
Total no. helminths	5	0	25	-	8	30
Goniodes	0	0	0	-	0	0
Colinicola	0	0	0	-	0	0
Ornithomyia	0	0	0	-	0	0
Haemaphysalis	0	0	0	-	0	0
Tissue analyzed	-	B	B	OV	BM	-
Heptachlor	-	0.190	0	0	0	-
Heptachlor epoxide	-	0	0	0	0	-
Dieldrin	-	0	0	0	0.032	-
DDD	-	0	0	0.024	0.041	-
DDE	-	0.195	0.234	0.480	0.014	-
DDT	-	0.488	0.005	0.312	0.005	-
Lindane	-	0	0	0	0	-
Endrin	-	0	0	0	0	-
Methoxychlor	-	0	0	0	0	-
Total residue	-	0.864	0.216	0.766	0.084	-
Emaciation index	96	90	87	-	90	103

1965 specimens

Specimen number	C-13	C-14	C-14a	C-14b	C-15	C-16
Area collected	2	2	2	2	2	4
Date	6/12	6/12	6/12	6/12	6/12	6/13
Age	Imm.	Imm.	-	-	Imm.	Ad.
Sex	M	F	-	-	M	M
Weight in grams	174.8	190.8	-	-	162.3	177.0
Rhabdometra	7	0	-	-	56	0
Choanothaenia	0	0	-	-	0	0
Acuaria	0	0	-	-	0	0
Total no. helminths	7	0	-	-	56	0
Goniodes	0	0	-	-	0	0
Colinicola	0	0	-	-	0	0
Ornithomyia	0	0	-	-	0	0
Haemaphysalis	0	0	-	-	0	0
Tissue analyzed	-	B	OV	E	-	-
Heptachlor	-	0	0	0	-	-
Heptachlor epoxide	-	0	0	0	-	-
Dieldrin	-	0	0	0.465	-	-
DDD	-	0.158	0.099	0.136	-	-
DDE	-	0.417	0.560	2.88	-	-
DDT	-	0.295	0.708	0.573	-	-
Lindane	-	0	0	0	-	-
Endrin	-	0	0	0	-	-
Methoxychlor	-	0	0	0	-	-
Total residue	-	0.822	1.291	3.783	-	-
Emaciation index	97	90	-	-	100	83

1965 specimens

Specimen number	C-17	C-18	C-19	C-20	C-21	C-21a
Area collected	2	2	3	3	2	2
Date	6/14	6/26	6/27	6/27	6/28	6/28
Age	Imm.	Ad.	5 wks.	2 wks.	Ad.	-
Sex	M	M	M	F	F	-
Weight in grams	140.0	169.2	70.3	12.6	224.4	-
Rhabdometra	7	15	0	0	0	-
Choanotaenia	0	0	0	0	0	-
Acuaria	0	0	0	0	6	-
Total no. helminths	7	15	0	0	6	-
Goniodes	0	0	0	0	0	-
Colinicola	0	0	0	0	0	-
Ornithomyia	0	0	0	0	0	-
Haemaphysalis	0	0	0	0	0	-
Tissue analyzed	-	-	B	-	B	OV
Heptachlor	-	-	0	-	0	0
Heptachlor epoxide	-	-	0	-	0	0
Dieldrin	-	-	0	-	0	1.30
DDD	-	-	0	-	0.066	0.084
DDE	-	-	0.005	-	0.600	3.06
DDT	-	-	0.005	-	0	1.19
Lindane	-	-	0	-	0	0
Endrin	-	-	0	-	0	0
Methoxychlor	-	-	0	-	0	0
Total residue	-	-	0.010	-	0.599	5.406
Emaciation index	110	100	-	-	-	-

1965 specimens

Specimen number	C-22	C-23	C-24	C-25	C-26	C-27
Area collected	2	2	3	2	2	2
Date	6/28	6/28	6/30	7/1	7/2	7/2
Age	Ad.	Imm.	Ad.	Ad.	4 wks.	1 wk.
Sex.	M	M	M	M	F	F
Weight in grams	174.6	188.3	195.9	180.0	54.3	7.6
Rhabdometra	12	0	0	12	0	0
Choanothaenia	0	0	0	0	0	0
Acuaria	0	0	0	3	0	0
Total no. helminths	12	0	0	15	0	0
Goniodbs	0	0	0	0	0	0
Colinicola	0	0	0	0	0	0
Ornithomyia	0	0	0	0	0	0
Haemaphysalis	0	0	0	0	0	0
Tissue analyzed	-	-	-	-	B	B
Heptachlor	-	-	-	-	0	0.248
Heptachlor epoxide	-	-	-	-	0	0
Dieldrin	-	-	-	-	0	0
DDD	-	-	-	-	0	0
DDE	-	-	-	-	0.280	0.726
DDT	-	-	-	-	0.005	0
Lindane	-	-	-	-	0	0
Endrin	-	-	-	-	0	0
Methoxychlor	-	-	-	-	0	0
Total residue	-	-	-	-	0.257	0.913
Emaciation index	106	88	109	108	-	-

1965 specimens

Specimen number	C-29	C-30	C-31	C-32	C-33	C-34
Area collected	2	2	2	2	2	2
Date	7/3	7/3	7/3	7/4	7/6	7/6
Age	Imm.	5 wks.	Imm.	4 wks.	5 wks.	Imm.
Sex	F	F	M	M	F	F
Weight in grams	198.2	95.4	186.7	39.3	72.5	184.2
Rhabdometra	0	5	0	25	30	0
Choanotaenia	0	0	0	0	0	0
Acuaria	0	0	0	0	0	0
Total no. helminths	0	5	0	25	30	0
Goniodes	0	0	0	0	0	0
Colinicola	0	0	0	X	X	0
Ornithomyia	0	0	0	0	0	0
Haemaphysalis	0	0	0	0	0	0
Tissue analyzed	B	B	-	B	B	B
Heptachlor	0.554	0	-	0	0.248	0
Heptachlor epoxide	0.005	0	-	0	0	0
Dieldrin	0	0.010	-	0	0	0
DDD	0	0.005	-	0	0	0.066
DDE	0.825	0.024	-	0.280	0.726	0.600
DDT	0	0.005	-	0.005	0	0
Lindane	0	0	-	0	0	0
Endrin	0	0	-	0	0	0
Methoxychlor	0	0	-	0	0	0
Total residue	1.331	0.043	-	0.257	0.913	0.599
Emaciation index	-	-	-	93	75	120

1965 specimens

Specimen number	C-35	C-36	C-37	C-38	C-39	C-40
Area collected	2	3	4	4	4	4
Date	7/6	7/12	7/12	7/12	7/14	7/14
Age	Imm.	Ad.	5 wks.	5 wks.	5 wks.	5 wks.
Sex	M	F	M	F	M	M
Weight in grams	162.2	222.5	60.1	46.7	63.8	48.5
Rhabdometra	X	X	0	0	0	0
Choanothaenia	0	0	0	0	0	0
Acuaria	0	0	0	0	0	0
Total no. helminths	?	?	0	0	0	0
Goniodes	0	0	0	0	0	0
Colinicola	0	0	X	0	X	X
Ornithomyia	0	0	0	X	0	0
Haemaphysalis	0	0	0	0	0	0
Tissue analyzed	-	BM	B	B	B	B
Heptachlor	-	0.012	0	0	0	0
Heptachlor epoxide	-	0.026	0.005	0	0	0
Dieldrin	-	0.010	0	0	0	0
DDD	-	0.044	0	0	0	0
DDE	-	0.061	0	0	0	0
DDT	-	0.129	0	0	0	0
Lindane	-	0.100	0	0	0	0
Endrin	-	0	0	0	0	0
Methoxychlor	-	0	0	0	0	0
Total residue	-	0.359	0.006	0	0	0
Emaciation index	-	-	-	-	91	56

1965 specimens

Specimen number	C-41	C-41a	C-42	C-43	C-44	C-45
Area collected	2	2	2	3	3	3
Date	7/15	7/15	7/25	7/25	7/26	7/26
Age	Ad.	-	Imm.	8 wks.	5 wks.	5 wks.
Sex	F	-	M	M	F	F
Weight in grams	214.3	-	192.9	129.7	60.5	56.5
Rhabdometra	3	-	0	0	0	0
Choanotaenia	0	-	0	0	0	2
Acuaria	0	-	0	0	0	0
Total no. helminths	3	-	0	0	0	2
Goniodes	0	-	0	0	0	0
Colinicola	0	-	0	0	0	0
Ornithomyia	0	-	0	0	0	0
Haemaphysalis	0	-	0	0	0	0
Tissue analyzed	BM	OV	-	B	B	B
Heptachlor	0	0	-	0.093	0.125	0.098
Heptachlor epoxide	0	0	-	0	0.041	0
Dieldrin	0.016	0.465	-	0	0.057	0.047
DDD	0	0.136	-	0.094	0.147	0.085
DDE	0.025	2.88	-	0.005	0.074	0.079
DDT	0.005	0.573	-	0.005	0.124	0.005
Lindane	0	0	-	0	0	0
Endrin	0	0	-	0	0	0
Methoxychlor	0	0	-	0	0	0
Total residue	0.045	3.783	-	0.193	0.560	0.306
Emaciation index	90.5	-	92.3	96.6	105.5	100

1965 specimens

Specimen number	C-46	C-47	C-47a	C-50	C-51	C-52
Area collected	2	2	2	2	1	1
Date	7/27	7/27	7/27	7/28	8/2	8/2
Age	Ad.	Imm.	-	Ad.	Imm.	Ad.
Sex	M	F	-	M	M	F
Weight in grams	191.7	194.9	-	193.4	177.2	159.5
Rhabdometra	0	0	-	2	2	0
Choanotaenia	0	0	-	0	0	0
Acuaria	0	5	-	0	0	0
Total no. helminths	0	5	-	2	2	0
Goniodes	0	0	-	0	0	0
Colinicola	0	0	-	0	0	0
Ornithomyia	0	0	-	0	0	0
Haemaphysalis	0	0	-	0	0	0
Tissue analyzed	-	B	OV	-	-	B
Heptachlor	-	0.005	0	-	-	0.186
Heptachlor epoxide	-	0	0	-	-	0
Dieldrin	-	0	0.178	-	-	0
DDD	-	0	0	-	-	0
DDE	-	0.105	0.288	-	-	0.348
DDT	-	0	0.005	-	-	0
Lindane	-	0	0	-	-	0
Endrin	-	0	0	-	-	0
Methoxychlor	-	0	0	-	-	0
Total residue	-	0.100	0.454	-	-	0.508
Emaciation index	107.9	110.6	-	-	94.7	97.1

1965 specimens

Specimen number	C-53	C-54	C-55	C-56	C-57	C-58
Area collected	1	1	1	1	4	4
Date	8/2	8/2	8/2	8/2	8/3	8/3
Age	9 wks.	9 wks.	9 wks.	9 wks.	Imm.	Imm.
Sex	M	M	F	F	M	F
Weight in grams	142.4	127.1	126.1	119.0	177.0	168.6
Rhabdometra	10	0	1	10	1	0
Choanotaenia	0	0	0	0	0	0
Acuaria	0	0	0	0	0	0
Total no. helminths	10	0	1	10	1	0
Goniodes	0	0	0	0	0	0
Colinicola	0	0	0	0	0	0
Ornithomyia	0	0	0	0	0	0
Haemaphysalis	0	0	0	0	0	0
Tissue analyzed	B	B	BM	B	-	B
Heptachlor	0.418	0.227	0.012	0.227	-	0.005
Heptachlor epoxide	0.005	0	0	0	-	0
Dieldrin	0	0	0	0	-	0
DDD	0	0	0.041	0	-	0
DDE	0.348	0.302	0.040	0.302	-	0
DDT	0.005	0.814	0.040	0.814	-	0
Lindane	0	0	0	0	-	0
Endrin	0	0	0	0	-	0
Methoxychlor	0	0	0	0	-	0
Total residue	0.796	1.324	0.126	1.324	-	0.005
Emaciation index	100	93.3	73.3	100	118.8	108.8

1965 specimens

Specimen number	C-59	C-60	C-61	C-62	C-63	C-64
Area collected	4	1	1	3	3	1
Date	8/3	8/7	8/9	8/10	8/10	8/10
Age	6 wks.	10 wks.	Imm.	Ad.	Imm.	Ad.
Sex	M	F	F	M	F	M
Weight in grams	83.4	117.4	179.0	199.3	154.6	165.7
Rhabdometra	0	0	1	2	0	0
Choanotaenia	0	0	0	0	0	0
Acuaria	0	0	0	0	0	0
Total no. helminths	0	0	1	2	0	0
Goniodes	0	0	0	0	0	0
Colinicola	X	0	0	0	0	0
Ornithomyia	0	0	0	0	0	0
Haemaphysalis	0	0	0	0	0	0
Tissue analyzed	B	B	B	-	B	-
Heptachlor	0	0.373	0.391	-	0.131	-
Heptachlor epoxide	0	0	0	-	0.085	-
Dieldrin	0	0	0.005	-	0.094	-
DDD	0	0.005	0.005	-	0	-
DDE	0	1.26	0.397	-	0.005	-
DDT	0	0.005	0.542	-	0.161	-
Lindane	0	0	0	-	0	-
Endrin	0	0	0	-	0.005	-
Methoxychlor	0	0	0	-	0	-
Total residue	0	1.532	1.319	-	0.503	-
Emaciation index	-	83.9	90.7	108.3	-	94.4

1965 specimens

Specimen number	C-65	C-66	C-67	C-68	C-69	C-70
Area collected	1	1	1	3	3	3
Date	8/10	8/10	8/10	8/11	8/11	8/11
Age	Imm.	11 wks.	8 wks.	7 wks.	7 wks.	7 wks.
Sex	F	M	M	F	F	F
Weight in grams	158.8	157.2	127.9	110.3	96.9	103.6
Rhabdometra	2	0	5	0	0	0
Choanotaenia	0	0	0	0	0	1
Acuaria	0	0	0	0	0	0
Total no. helminths	2	0	5	0	0	1
Goniodes	0	0	0	0	0	0
Colinicola	0	0	0	0	X	X
Ornithomyia	0	0	0	0	0	0
Haemaphysalis	0	0	0	0	0	0
Tissue analyzed	B	B	B	BM	B	B
Heptachlor	0.438	0	0.005	0	0.067	0.044
Heptachlor epoxide	0	0	0	0	0	0
Dieldrin	0.200	0.005	0	0	0	0
DDD	0.108	0	0	0	0	0
DDE	0.916	0.326	0.234	0.047	0	0
DDT	0.242	0.566	0	0	0	0
Lindane	0	0	0	0	0	0
Endrin	0	0	0	0	0	0
Methoxychlor	0	0	0	0	0	0
Total residue	1.837	0.864	0.218	0.042	0.070	0.046
Emaciation index	-	105.9	96.6	96.6	114.3	92.3

1965 specimens

Specimen number	C-71	C-72	C-73	C-74	C-75	C-76
Area collected	3	3	3	3	1	1
Date	8/11	8/11	8/13	8/13	8/13	8/13
Age	6 wks.	7 wks.	8 wks.	8 wks.	11 wks.	11 wks.
Sex	M	M	M	F	M	F
Weight in grams	107.6	95.5	124.1	120.1	160.1	149.3
Rhabdometra	0	0	0	0	0	25
Choanotaenia	2	0	3	0	0	0
Acuaria	0	0	0	0	0	0
Total no. helminths	2	0	3	0	0	25
Goniodes	0	X	0	0	0	0
Colinicola	X	X	0	X	0	0
Ornithomyia	0	0	0	0	0	0
Haemaphysalis	0	X	0	0	0	0
Tissue analyzed	B	B	B	B	B	B
Heptachlor	0.079	0.005	0.005	0.062	0.115	0
Heptachlor epoxide	0	0	0	0	0	0
Dieldrin	0	0	0.005	0	0.309	0
DDD	0	0.342	0	0	0	0.005
DDE	0	0.087	0.306	0	0.561	0.257
DDT	0	0.005	0	0	0.005	0.005
Lindane	0	0	0	0	0	0
Endrin	0	0	0	0	0	0
Methoxychlor	0	0	0	0	0	0
Total residue	0.083	0.396	0.285	0.065	0.962	0.241
Emaciation index	88.0	80.8	86.5	94.1	92.3	86.5

1965 specimens

Specimen number	C-77	C-78	C-79	C-80	C-81	C-82
Area collected	1	1	1	1	1	1
Date	8/13	8/13	8/13	8/13	8/13	8/13
Age	10 wks.	10 wks.	10 wks.	10 wks.	9 wks.	10 wks.
Sex	F	F	M	F	F	F
Weight in grams	114.8	146.9	142.9	130.3	123.0	140.3
Rhabdometra	1	26	0	1	17	17
Choanotaenia	0	0	0	0	0	0
Acuaria	0	0	0	0	0	0
Total no. helminths	1	26	0	1	17	17
Goniodes	0	0	0	0	0	0
Colinicola	0	0	0	X	0	0
Ornithomyia	0	0	0	0	0	0
Haemaphysalis	0	0	0	0	0	0
Tissue analyzed	B	B	B	B	B	B
Heptachlor	0	0	0	0.005	0.217	0
Heptachlor epoxide	0	0	0	0	0	0
Dieldrin	0	0.005	0	0	0	0.005
DDD	0	0	0	0	0	0
DDE	0.387	0.188	0.005	0.179	0.131	0.192
DDT	0.005	0.005	0	0	0	0.348
Lindane	0	0	0	0	0	0
Endrin	0	0	0	0	0	0
Methoxychlor	0	0	0	0	0	0
Total residue	0.353	0.179	0.005	0.166	0.341	0.536
Emaciation index	100	87.5	92.0	83.3	100	91.2

1965 specimens

Specimen number	C-83	C-84	C-85	C-86	C-87	C-88
Area collected	1	1	1	1	3	3
Date	8/13	8/13	8/14	8/14	8/14	8/14
Age	10 wks.	9 wks.	13 wks.	10 wks.	Ad.	Imm.
Sex	F	M	M	M	M	F
Weight in grams	139.0	135.6	153.9	155.8	196.5	157.7
Rhabdometra	30	42	3	31	0	0
Choanotaenia	0	0	0	0	0	2
Acuaria	0	0	0	0	0	0
Total no. helminths	30	42	3	31	0	2
Goniodes	0	0	0	0	0	0
Colinicola	X	0	0	0	0	0
Ornithomyia	0	0	0	0	0	0
Haemaphysalis	0	0	0	0	0	0
Tissue analyzed	B	B	B	B	-	B
Heptachlor	0	0	0.099	0	-	0.005
Heptachlor epoxide	0	0	0	0	-	0
Dieldrin	0	0.144	0	0.310	-	0
DDD	0	0	0	0	-	0
DDE	0.150	0.223	0.130	0.171	-	0.005
DDT	0.005	0.278	0	0.618	-	0
Lindane	0	0	0	0	-	0
Endrin	0	0	0	0	-	0
Methoxychlor	0	0	0	0	-	0
Total residue	0.140	0.633	0.221	1.104	-	0.010
Emaciation index	88.2	94.1	111.8	94.1	88.8	85.7

1965 specimens

Specimen number	C-89	C-90	C-91	C-92	C-93	C-94
Area collected	3	3	3	3	1	1
Date	8/14	8/14	8/14	8/14	8/22	8/22
Age	4 wks.	Ad.	5 wks.	5 wks.	10 wks.	Ad.
Sex	M	M	M	F	F	M
Weight in grams	50.2	162.4	64.8	67.2	140.2	172.4
Rhabdometra	0	1	0	0	0	1
Choanotaenia	2	0	1	0	0	0
Acuaria	0	0	0	0	0	0
Total no. helminths	2	1	1	0	0	1
Goniodes	0	0	0	0	0	0
Colinicola	X	0	X	X	X	X
Ornithomyia	0	0	0	0	0	0
Haemaphysalis	0	0	0	0	0	0
Tissue analyzed	B	-	B	B	B	-
Heptachlor	0.005	-	0.005	0.005	0	-
Heptachlor epoxide	0	-	0	0	0	-
Dieldrin	0	-	0	0	0	-
DDD	0	-	0	0	0	-
DDE	0	-	0.005	0.005	0.114	-
DDT	0	-	0	0	0.244	-
Lindane	0	-	0	0	0	-
Endrin	0	-	0	0	0	-
Methoxychlor	0	-	0	0	0	-
Total residue	0.005	-	0.010	0.010	0.347	-
Emaciation index	77.8	83.3	84.2	75.0	94.1	112.4

1965 specimens

Specimen number	C-95	C-96	C-97	C-98	C-99	C-100
Area collected	1	1	1	1	1	1
Date	8/26	8/26	8/26	8/26	8/26	8/26
Age	10 wks.	12 wks.	Ad.	12 wks.	10 wks.	10 wks.
Sex	F	F	M	F	M	M
Weight in grams	153.7	154.5	166.3	166.2	128.3	146.4
Rhabdometra	9	24	3	X	62	27
Choanotaenia	0	0	0	0	0	0
Acuaria	0	0	0	0	0	0
Total no.helminths	9	24	3	?	62	27
Goniodes	0	0	0	0	0	0
Colinicola	0	X	0	0	0	0
Ornithomyia	0	0	0	0	0	0
Haemaphysalis	0	0	0	0	0	0
Tissue analyzed	B	B	-	B	B	B
Heptachlor	0	0	-	0.005	0.036	0.031
Heptachlor epoxide	0	0	-	0.115	0.110	0.106
Dieldrin	0.046	0	-	0	0	0
DDD	0.099	0	-	0	0	0
DDE	0.143	0.024	-	0.311	0.108	0.311
DDT	0.189	0	-	0.365	0	0
Lindane	0	0	-	0	0	0
Endrin	0	0	-	0	0	0
Methoxychlor	0	0	-	0	0	0
Total residue	0.456	0.022	-	0.777	0.256	0.430
Emaciation index	100	83.5	94.1	92.1	96.7	97.1

1965 specimens

Specimen number	C-101	C-102	C-103	C-104	C-105	C-106
Area collected	1	1	1	1	1	1
Date	8/26	8/26	9/4	9/6	9/6	9/6
Age	10 wks.	10 wks.	6 wks.	6 wks.	Ad.	6 wks.
Sex	M	M	F	M	M	M
Weight in grams	143.6	142.6	82.0	91.0	186.8	94.4
Rhabdometra	45	27	32	16	3	69
Choanotaenia	0	0	0	0	0	0
Acuaria	0	0	0	0	0	0
Total no. helminths	45	27	32	16	3	69
Goniodes	0	0	0	0	X	0
Colinicola	0	0	X	X	X	X
Ornithomyia	0	0	0	0	0	0
Haemaphysalis	0	0	0	0	0	0
Tissue analyzed	B	B	B	B	-	B
Heptachlor	0.055	0.005	0	0.043	-	0.121
Heptachlor epoxide	0.100	0.123	0.194	0.080	-	0.110
Dieldrin	0	0	0	0.005	-	0
DDD	0	0	0	0	-	0
DDE	0	0.199	0.718	0.103	-	0.172
DDT	0	0	0	0.005	-	0.005
Lindane	0	0	0	0	-	0
Endrin	0	0	0	0	-	0
Methoxychlor	0	0	0	0	-	0
Total residue	0.168	0.319	0.850	0.236	-	0.408
Emaciation index	93.1	97.6	84.6	100	100	72.7

1965 specimens

Specimen number	C-107	C-108	C-109	C-110
Area collected	1	1	1	1
Date	9/6	9/7	9/7	9/8
Age	6 wks.	7 wks.	7 wks.	7 wks.
Sex	M	F	F	F
Weight in grams	92.8	122.1	102.5	125.9
Rhabdometra	10	16	16	52
Choanotaenia	0	0	0	0
Acuaria	0	0	0	0
Total no. helminths	10	16	16	52
Goniodes	0	0	0	X
Colinicola	X	X	X	X
Ornithomyia	0	0	0	0
Haemaphysalis	0	0	0	0
Tissue analyzed	B	B	B	B
Heptachlor	0.039	0.562	0.069	0.005
Heptachlor epoxide	0.065	0.078	0	0
Dieldrin	0	0	0	0.053
DDD	0.005	0	0	0
DDE	0.176	0.119	0.128	0.063
DDT	0.412	0.208	0	0
Lindane	0	0	0	0
Endrin	0	0	0	0
Methoxychlor	0	0	0	0
Total residue	0.688	0.991	0.187	0.121
Emaciation index	90.9	107.1	81.2	106.7

1966 specimens. The pesticide analyses on these specimens is not yet completed.

Specimen number	C-111	C-112	C-113	C-114	C-115	C-116
Area collected	1	1	1	1	1	2
Date	5/9	5/9	5/10	5/11	5/11	5/11
Age	Imm.	Ad.	Ad.	Imm.	Imm.	Imm.
Sex	F	M	M	F	M	F
Weight in grams	201.5	189	167	173	177	211.5
Rhabdometra	12	3	7	5	3	0
Choanotaenia	0	0	0	0	0	0
Acuaria	0	0	0	0	0	0
Total no. helminths	12	3	7	5	3	0
Goniodes	0	0	0	0	0	0
Colinicola	0	0	0	0	X	0
Ornithomyia	0	0	0	0	0	0
Haemaphysalis	0	0	0	0	0	0
Emaciation index	94.7	97.8	97.5	84.2	97.4	-

1966 specimens. The pesticide analyses on these specimens is not yet completed.

Specimen number	C-117	C-118	C-119	C-120	C-121	C-122
Area collected	2	1	1	1	1	3
Date	5/11	6/6	6/6	6/8	6/8	7/20
Age	Imm.	Imm.	Imm.	Imm.	Imm.	Imm.
Sex	M	F	F	F	M	F
Weight in grams	181	183	189	209	175	188
Rhabdometra	0	17	27	0	0	0
Choanotaenia	0	0	0	0	0	0
Acuaria	0	0	0	0	0	0
Total no. helminths	0	17	27	0	0	0
Goniodes	0	0	0	0	0	0
Colinicola	0	0	0	0	0	0
Ornithomyia	0	0	0	0	0	0
Haemaphysalis	0	0	0	0	0	0
Emaciation index	94.4	80.0	100	87.5	84.6	105.9

1966 specimens. The pesticide analyses on these specimens is not yet completed.

Specimen number	C-123	C-124	C-125	C-126	C-127	C-128
Area collected	3	3	3	3	3	3
Date	7/20	7/20	7/21	7/25	7/25	7/25
Age	Imm.	Imm.	Imm.	Imm.	7 wks.	7 wks.
Sex	F	M	M	M	F	M
Weight in grams	180	175	178	171	91	92
Rhabdometra	0	0	0	0	0	0
Choanotaenia	0	0	0	0	0	0
Acuaria	0	0	0	0	0	0
Total no. helminths	0	0	0	0	0	0
Goniodes	0	0	0	0	0	0
Colinicola	0	0	0	0	0	X
Ornithomyia	0	0	0	0	0	0
Haemaphysalis	0	0	0	0	0	0
Emaciation index	100	-	85.0	75.0	77.3	91.7

1966 specimens. The pesticide analyses on these specimens is not yet completed.

Specimen number	C-129	C-130*	C-131	C-132	C-133	C-134*
Area collected	3	3	3	3	3	3
Date	7/25	8/1	8/1	8/1	8/1	8/2
Age	7 wks.	6 wks.	Ad.	7 wks.	10 wks.	7 wks.
Sex	M	F	M	F	M	F
Weight in grams	105	42	174	112	139	46
Rhabdometra	0	0	0	0	X	0
Choanotaenia	0	0	0	0	0	0
Acuaria	0	0	0	0	0	0
Total no. helminths	0	0	0	0	?	0
Goniodes	0	0	0	0	0	0
Colinicola	X	0	0	0	0	X
Ornithomyia	0	0	0	0	0	0
Haemaphysalis	0	0	0	0	0	0
Emaciation index	91.7	-	94.1	81.8	87.5	16.7

* C-130 and C-134 starved to death, autopsied on dates shown

C-130 collected July 25, 1966 - lived 7 days

C-134 collected July 25, 1966 - lived 8 days

1966 specimens. The pesticide analyses on these specimens is not yet completed.

Specimen number	C-135*	C-136	C-137	C-138	C-139	C-140
Area collected	3	3	3	1	1	3
Date	8/5	8/4	8/4	8/6	8/6	8/31
Age	7 wks.	7 wks.	8 wks.	9 wks.	7 wks.	Ad.
Sex	F	F	F	M	F	M
Weight in grams	64	104	113	104	99	152
Rhabdometra	0	0	0	0	0	0
Choanotaenia	0	0	1	0	0	0
Acuaria	0	0	0	0	0	0
Total no. helminths	0	0	1	0	0	0
Goniodes	0	0	0	0	0	0
Colinicola	0	X	X	0	0	0
Ornithomyia	0	0	0	0	0	0
Haemaphysalis	0	0	0	0	0	0
Emaciation index	-	75.0	85.7	85.7	78.6	85.7

* C-135 starved to death, autopsied on date shown

C-135 collected July 25, 1966 - lived 11 days

1966 specimens. The pesticide analyses on these specimens is not yet completed.

Specimen number	C-141
Area collected	1
Date	9/3
Age	7 wks.
Sex	M
Weight in grams	119
Rhabdometra	0
Choanotaenia	0
Acuaria	0
Total no. helminths	0
Goniodes	0
Colinicola	0
Ornithomyia	0
Haemaphysalis	0
Emaciation index	84.6